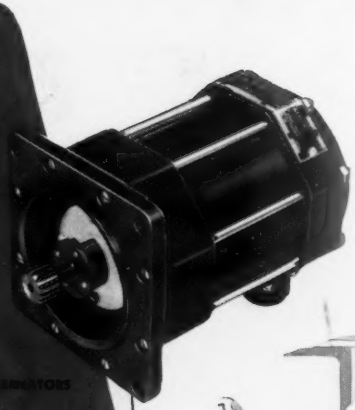
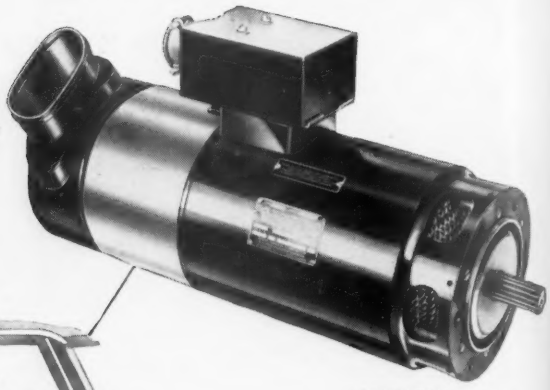
AERONAUTICAL ENGINEERING REVIEW

MAY 1950

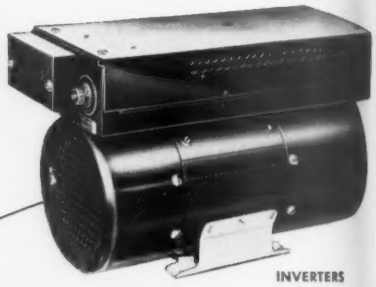
Flight Propulsion Issue



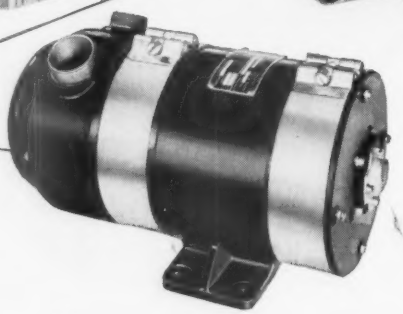
ALTERNATORS



GENERATORS



INVERTERS



VOLTAGE BOOSTER DYNAMOTORS

POWER SUPPLY GENERATING EQUIPMENT

Engine Control Equipment
Engine Starting Equipment
Air Pumps
Hydraulic Equipment
Ice Elimination Equipment
Power Supply Regulating Equipment

★

Automatic Pilots
Flight Path Control Systems
Engine Instruments
Flight Instruments
Navigation Instruments

Current You Can Count On!

From "switch-on" to "switch-off", the efficient operation of complex modern aircraft depends on reliable electric power. That is why Eclipse-Pioneer Power Supply Generating Equipment is the choice of plane manufacturers and airlines around the world. For Eclipse-Pioneer is backed by the oldest and finest reputation in its field, providing a line of products unsurpassed in progressive engineering and precision construction. When you choose your electrical power sources get the best, Eclipse-Pioneer—for current you can count on.

ECLIPSE-PIONEER DIVISION OF

TETERBORO, NEW JERSEY

Bendix
AVIATION CORPORATION

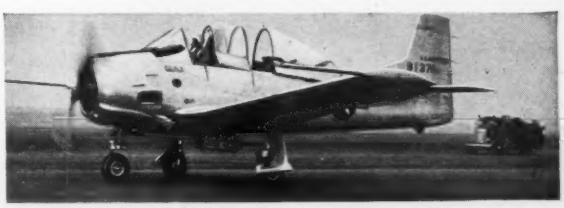
LOOK FOR THE MARK OF QUALITY

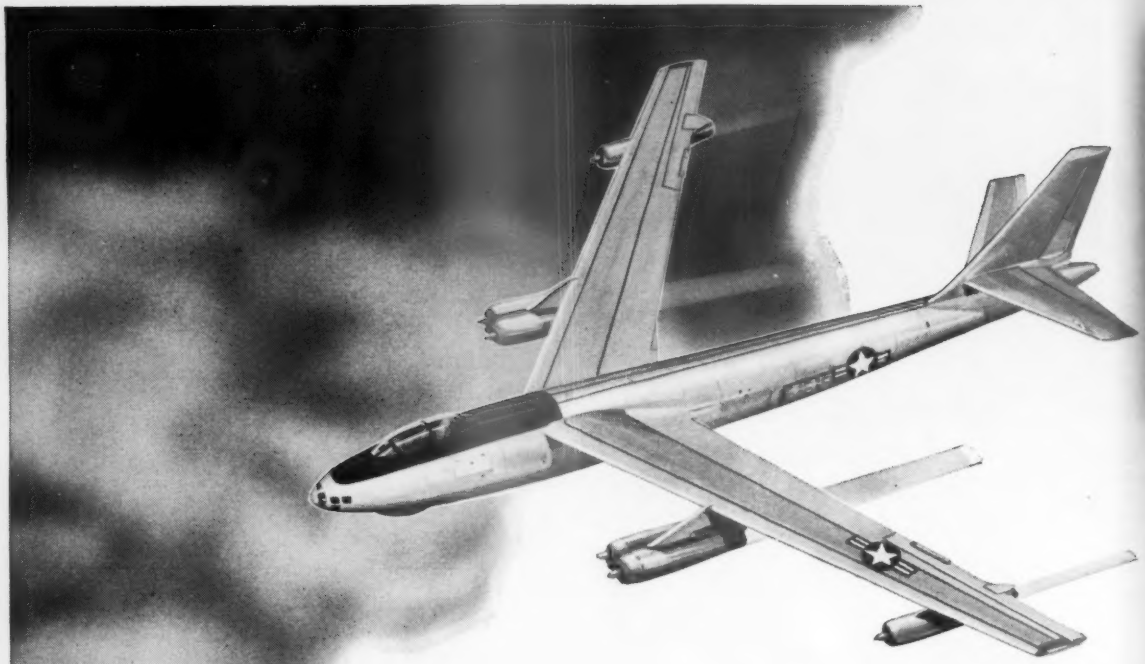
REG. U.S. PAT. OFF.

GOODYEAR
AVIATION
PRODUCTS

Two good reasons why this trainer's rugged

PROBABLY no type of aircraft takes more daily punishment than a trainer. That's why, on North American's new T-28, Goodyear Single Disc Brakes and super-strong, lightweight magnesium alloy wheels were selected. For these time-tested, time-proved Goodyear products are first choice with manufacturers, owners and operators all over the world. The Goodyear Single Disc Brake provides maximum energy absorption in minimum space, is self-adjusting, self-cooling, non-fading, requires minimum maintenance. Goodyear magnesium alloy wheels combine tremendous strength with light weight. Proof is the fact: More aircraft are equipped with Goodyear wheels and brakes than any other kind. For details, write: Aviation Products Division, Goodyear, Akron 16, Ohio or Los Angeles 54, California.





Behind the scenes on the B-47

Here is the Boeing B-47—the sleek jet-propelled bomber that eats up distance at a rate of more than 10 miles per minute.

Operating such a swift air giant demands a range of controls that must represent the last word in quality.

Boeing looks to Foote Bros. for the production of actuators and power units which are aiding in the amazing performance of this master of the skies.

On many of America's leading aircraft and aircraft engines, you will find equipment manufactured by Foote Bros. —chosen because of the years of experience of this company in producing gears and actuators light in weight, achieving new extremes in accuracy, capable of traveling at high speed, designed to fit a confined space envelope.

FOOTE BROS. GEAR AND MACHINE CORPORATION
Dept. G • 4545 South Western Boulevard • Chicago 9, Ill.

Landing Gear Actuator—One of the Units Produced by Foote Bros. for the Boeing B-47.

FOOTE BROS.

Better Power Transmission Through Better Gears

Cover—The 956-bladed, seven-stage, 87,000-hp. compressor at the 8- by 6-Ft. Supersonic Tunnel, Lewis Flight Propulsion Laboratory, N.A.C.A., Cleveland.

Editor
Welman A. Shrader

Technical Advisers
Hugh L. Dryden
Robert R. Dexter
S. Paul Johnston

Associate Editor
Berneice H. Jarck

Reviews Editor
Lyons T. Carr

Managing Editor
John J. Glennon

Assistant Reviews Editor
Harris F. Reeve

Manager
Joseph P. Ryan

Manager, Western Region
James L. Straight
7660 Beverly Blvd., Los Angeles 36, Calif.

SUBSCRIPTION RATES

Aeronautical Engineering Review: United States and possessions, 1 year, $3.00; single copies, $0.50. Foreign countries including Canada (American Currency Rates), 1 year, $3.50; single copies, $0.50.

Entered as second-class matter at the Post Office, Easton, Pa., April 29, 1942. Acceptance for mailing at a Special Rate of Postage as provided for in the Act of August 24, 1912.

Publication Office: 20th & Northampton Streets, Easton, Pa.

Editorial Office: 2 East 64th Street, New York 21, N.Y.

Notices of change of address should be sent to the Institute at least 30 days prior to actual change of address.

Statements and opinions expressed in the *Aeronautical Engineering Review* are to be understood as individual expressions and not those of the Institute.

Copyright, 1950, by the Institute of the Aeronautical Sciences, Inc.

AERONAUTICAL ENGINEERING REVIEW

Vol. 9 MAY, 1950 No. 5

Contents

I.A.S. News 5

Articles

A Test Pilot Looks at the Jets . . . . . Capt. F. M. Trapnell, U.S.N. 14

Aircraft Propulsion (A Report on the Fifth Annual Flight Propulsion Meeting) . . . . . S. Doree Black, A. L. Pomeroy, and Uwe H. von Glahn 20

Looking Ahead with Air Transport . Charles Froesch 34

I.A.S. Briefs 45

Reviews

Aeronautical Reviews 49

Books 71

I.A.S. Preprints 47

Special I.A.S. Publications 76

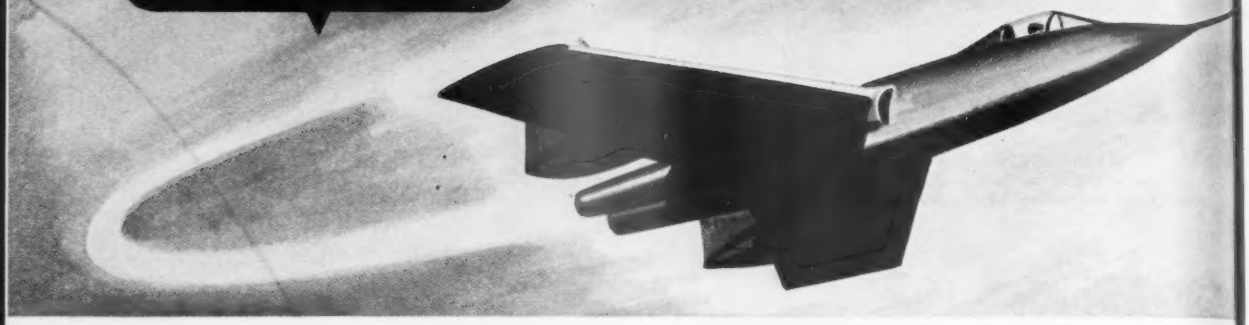
Personnel Opportunities 91

Index to Advertisers 95

Published Monthly by the Institute of the Aeronautical Sciences, Inc.

Bendix Products Division

FIRST IN FUEL METERING



Setting the Pace in America's Most Progressive Industry!

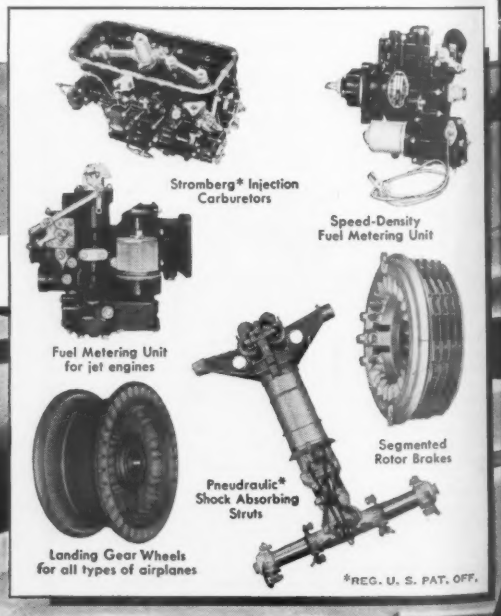
Tomorrow's aircraft—jets of unbelievable speeds, transports of gigantic size—are now on the drawing boards. And the task of creating new fuel metering systems and landing gear for many of these planes-in-the-making has been entrusted to the Bendix Products Division of Bendix Aviation Corporation.

Here, at Bendix Products, is a proved combination of creative engineering and quality production in these highly specialized fields. Let this Bendix skill and experience in the development of carburetion, fuel metering, shock-absorbing struts, wheels and brakes help you keep America's aviation the leader of the world.

BENDIX · PRODUCTS DIVISION · SOUTH BEND
AVIATION CORPORATION

Export Sales: Bendix International Division, 72 Fifth Ave., New York 11, N. Y.

LEADER IN LANDING GEAR


Stromberg* Injection Carburetors
Speed-Density Fuel Metering Unit
Fuel Metering Unit for jet engines
Segmented Rotor Brakes
Pneudraulic* Shock Absorbing Struts
Landing Gear Wheels for all types of airplanes
*REG. U. S. PAT. OFF.

I.A.S. News

A Record of People and Events of Interest to Institute Members

Helicopter Activities

I.A.S. Cooperates in Sixth Annual Forum of the American Helicopter Society; To Participate in A.S.M.E. Helicopter Meeting in St. Louis.

As announced last month, the I.A.S. has embarked on active collaboration with the A.H.S. The headquarters of the A.H.S. have been moved to 2 E. 64th St., and Miss Mary Morgan, formerly of the staff of the Wings Club in New York, has joined the I.A.S. staff to act as Secretarial Assistant to the Officers of the A.H.S. Miss Morgan will also act as Secretary to the I.A.S. Archives.

▸ **Philadelphia Forum**—The forum on March 30–31 maintained the high technical standards that have been set by previous gatherings of this group. The program included a theoretical session on Thursday morning under the leadership of John W. Mazur, Naval Air Test Center, Patuxent River, Md. Five papers were presented on various aspects of aerodynamics, stability, and control of helicopters.

Ralph B. Lightfoot, Chief of Flight Research, Sikorsky Aircraft Division, United Aircraft Corporation, steered the afternoon session on helicopter design problems.

On Friday morning, a session under Lt. Comdr. William G. Knapp, U.S.-N.R., covered operating problems, carriage of mail, and operation of helicopters under Arctic conditions, as well as the military use of helicopters. The final session, presided over by H. Stever Tremper, Piasecki Helicopter Corporation, went into the economics of helicopter operations and wound up with a British film on the various uses of helicopters.

▸ **Proceedings To Be Published**—The *Proceedings* of the Sixth Annual Forum of the American Helicopter Society are in preparation. This volume will contain the full text of the papers, with illustrations, and will be available in a few months through the A.H.S.

▸ **Honors Banquet**—On the social side, there was a Pioneer's Dinner on Thursday evening and the usual A.H.S. Honors Banquet at 7:30 on Friday evening. Colonel H. Frank Gregory, U.S.A.F., acted as Toastmaster, and Paul H. Stanley, Chief Engineer, Autogiro Company of America, presented the ten Honor Awards. Outstanding among the Honor Awards were those given to Frederic B. Gustafson, Aeronautical Research Scientist, N.A.C.A., Langley Air Force Base, for applied research; to Leon M. Douglas, Chief Engineer and General Manager, Kellett Aircraft Corporation, for mechanical design; and to David Driscoll, for helicopter piloting (awarded posthumously). Honorary Fellowships were bestowed on Stanley Hiller, Jr., President, Hiller Helicopters, and on Charles H. Kaman, President, The Kaman Aircraft Corporation. During the course of the dinner many tributes were paid to the memory of Dr. Alexander Klemin, the 1949 President of the A.H.S., who died on Tuesday, March 14.

The new officers of the A.H.S. were inducted at the dinner. The list includes: President, Frank H. Piasecki, President, Piasecki Helicopter Corporation; Secretary, Thomas R. Pierpoint, Service Manager, Piasecki Helicopter Corporation; Treasurer, Oliver B. Chittick, Staff Accountant, Sikorsky Aircraft Division, United Aircraft Corporation; Technical Chairman, Bartram Kelley, Chief Helicopter Engineer, Bell Aircraft Corporation; Membership Chairman, J. E. Beighle, Assistant Sales Manager, Sikorsky Aircraft Division, United Aircraft Corporation; and Publicity Chairman, E. J. Huber, Director, Public Relations, Piasecki Helicopter Corporation.

Elected: *Frank N. Piasecki, new A.H.S. President for 1950, will be luncheon speaker during A.S.M.E.-A.H.S.-I.A.S. helicopter day in St. Louis on June 20.*

▸ **St. Louis Meeting**—Another helicopter activity of interest to I.A.S. Members comes up on June 20 in a meeting at St. Louis, sponsored by the A.S.M.E., in which both the A.H.S. and the I.A.S. will participate. Frank N. Piasecki will be guest speaker at the noon luncheon.

Six papers will be read during the morning and afternoon sessions: "Flight Testing Helicopters for Dynamic Stability," by John O'Dea; "The Helicopter Pressure Jet," by Friedrich L. V. Doblhoff; "Hovering and Low-Speed Performance and Control Characteristics of an Aerodynamic Servo-Controlled Helicopter Rotor System," by Paul J. Carpenter; "Practical Flight Research as Performed by the Air Materiel Command," by Major Vernon Prentiss and Nathan R. Rosengarten; "Distribution of Airflow Through Single and Coaxial Model Helicopter Rotors in Static Thrust as Visualized by the Balsa Dust Technique," by Marion K. Taylor; and "An Analysis of Helicopter Propulsion Systems," by J. A. Johnson.

Martin 4-0-4's Ordered for E.A.L., T.W.A. Fleets; T.W.A. Leasing 2-0-2's

Captain E. V. Rickenbacker, President and General Manager, Eastern Air Lines, Inc., and Ralph S. Damon, President, Trans World Airline, announced on March 7 that orders had been placed with The Glenn L. Martin Company for 65 new Martin 4-0-4 40-passenger transports—35 for E.A.L., and 30 for T.W.A. Total value of the orders is estimated at $35,000,000. Deliveries are to begin in the spring of 1951.

▶ **Pressurized Cabin**—During flight at normal cruising altitudes, the air in the passenger cabin of the Martin 4-0-4 will be kept at sea-level pressure, and an air-conditioning system will maintain the proper temperature and humidity for maximum passenger comfort.

Two Pratt & Whitney R-2800 CB-16 engines, each delivering 2,400 hp. with water injection, will power the 4-0-4, and reversible propellers will be used. Maximum speed will be 312 m.p.h. at cruising altitudes.

Passengers will enter and leave the 4-0-4 by hydraulically operated built-in steps located under the tail of the fuselage. Carry-on baggage provisions will be available.

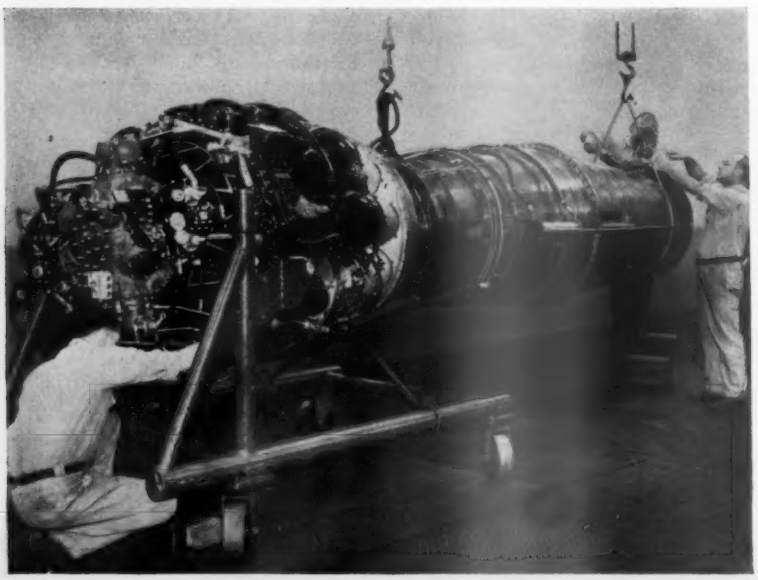
▶ **Jet Conversion**—The Martin 4-0-4 has been designed and stressed for conversion to turboprop engines when the latest power plants of this type are released by the Military Services for commercial use, which is expected within 3 to 5 years. The turboprop engine now being produced by the Allison Division, General Motors Corporation, could be used for such a conversion, which is expected to increase operating speed substantially and to extend the useful life of the aircraft by many years.

▶ **T.W.A. Lease**—In addition to purchasing 30 new 4-0-4 transports, Trans World Airline has completed arrangements with the Martin company to lease twelve Martin 2-0-2 transports, Ralph S. Damon announced on March 16. These 36-passenger twin-engined airplanes will go into service on T.W.A.'s medium- and short-haul domestic flights. Delivery of the 2-0-2's will start this July.

Pratt & Whitney Announces J-48 Turbo-Wasp

Pratt & Whitney Aircraft Division of United Aircraft Corporation has released details and a photograph of the J-48 Turbo-Wasp, which powers two of America's fastest aircraft—the Grumman F9F-5 Panther, an advanced model Navy carrier-based fighter, and the North American F-93A, a swept-wing penetration fighter built for the Air Force. This new Pratt & Whitney engine, termed the most powerful jet engine now flying in the United States, is a centrifugal-flow turbojet using a single-stage compressor with double-faced impeller and double air entries. It has a single-stage turbine and nine combustion chambers.

Most Powerful Turbojet: *First released photograph of Pratt & Whitney J-48 Turbo-Wasp, currently powering Grumman F9F-5 carrier-based and North American F-93A penetration fighters.*



▶ **5 Hp. per Lb.**—The J-48 has a basic dry rating of 6,250-lb. static thrust at sea level and is equipped with water injection and an afterburner. Kerosene, gasoline, or special jet fuels may be used. Overall diameter is 50 in. with a length of 8 ft. $10^3/_4$ in. without afterburner. Weight is less than 2,000 lbs. At the operating speeds of the fighters in which it is installed, the J-48 delivers the equivalent of 5 hp. per lb. of engine weight. This is in contrast to 1 hp. per lb. of engine weight from the most powerful piston engines.

The J-48 has powered more than 20 successful flights of the two fighters and has completed 1,800 hours of ground development testing, including two 150-hour endurance tests. Guaranteed power ratings were exceeded in these tests, both with and without afterburner.

A contract for 264 J-48 Turbo-Wasps for the Grumman F9F-5 has been placed by the Navy. Flight tests will be run from a Boeing B-29 carrying the J-48 with afterburner in its bomb bays. Production tooling is well under way at East Hartford, with full-scale production scheduled to begin in the summer.

Pratt & Whitney Aircraft Division and Rolls-Royce, Ltd., of England, pooled their engineering talents to develop the J-48. The British version, known as the Tay, will be installed in an experimental British jet transport. One of Pratt & Whitney's main independent contributions to the J-48 is the afterburner, which allows large increases in jet thrust for short periods, such as for take-off and for combat maneuvers.

▶ **Interchangeability**—In the J-48, increase in airflow is obtained without increase in the engine's diameter. A redesigned impeller in the compressor and longer turbine blades enable the engine to consume 30 per cent more air and thus produce more thrust. Dimensional differences of the J-48 and the earlier J-42 are slight, making the two engines essentially interchangeable. For example, both Turbo-Wasp models will go into the Grumman Panther.

Aircraft Manufacturers Win Safety Citations

In a safety contest sponsored by the Aeronautical Industries Section of the National Safety Council to reduce industrial injuries, Consolidated Vultee Aircraft Corporation, San Diego, Calif., took first place with a frequency rate of 1.68. Solar Aircraft Company, Des Moines, Iowa, and North American Aviation, Inc., Downey, Calif., took second and third

place with frequency rates of 1.92 and 2.18, respectively.

The cumulative rate for the entire year—January 1 to December 31, 1949—for all twelve contestants was 3.32, a reduction of 10 per cent from the final rate of 3.70 in the 1948–1949 contest, which covered 12 months ending June 30, 1949. The number of man-hours worked by the contestants in the present contest was practically unchanged from that of the previous contest; the number of disabling injuries, however, was reduced 10 per cent. In this year's contest, the twelve plants finishing reported a total exposure in excess of 175,000,000 man-hours during the year.

Consolidated Vultee will receive a First-Place Trophy; Solar and North American will receive Second-Place and Third-Place Certificates.

Northrop Special Weapons and Computing Departments

In a move to streamline engineering and research activities, Northrop Aircraft, Inc., has established two separate departments: a Special Weapons Department and a Computing Department. The Special Weapons Department, headed by S. E. Weaver, will conduct research and development projects outside the field of manned military aircraft. The Computing Department will use the new Binac electronic computer recently acquired by the company, in addition to other types of more conventional mechanical computing machines. Northrop Aircraft is the first industrial concern to acquire one of the Binacs, which can solve mathematical problems 12,000 times faster than a man using older mechanical methods.

In other organizational changes, Walter J. Cerny, A.F.I.A.S., formerly Director of Engineering, was elevated to Assistant to the President, and Warren G. Knieriem, a member of Northrop's Flying Wing design team, was named Chief Engineer.

Dr. Harrington Heads Aeronautical Engineering at Rensselaer

Dr. R. Paul Harrington, A.F.I.A.S., has been named Head of Aeronautical Engineering at Rensselaer Polytechnic Institute, Troy, N.Y. Dr. Harrington assumes his new post on July 1, succeeding Dr. Paul E. Hemke, A.F.I.A.S., who became Dean of Faculty at the opening of the present college year.

Since 1941, Dr. Harrington has been Head of Aeronautical Engineering and Applied Mechanics at Polytechnic

NECROLOGY

Dr. Alexander Klemin

Dr. Alexander Klemin, a Founder Member, Benefactor, and Fellow of the Institute, died suddenly on March 14 at his home in Greenwich, Conn.

▸ **Educator**—Dr. Klemin, who was Technical Editor of *Aero Digest* at the time of his death, was head of the Guggenheim School of Aeronautics at New York University College of Engineering from its founding in 1925 until his retirement in 1945. Among his former students are numbered many of the top-ranking aeronautical engineers in industry and research. For his contributions to aeronautical education, he was awarded the honorary degree of Doctor of Engineering by N.Y.U. on January 26, 1950.

▸ **Rotary-Wing Expert**—Long an expert on rotating wing aircraft and a spirited believer in their great potentialities, Dr. Klemin was also President of the American Helicopter Society when he died. As A.H.S. President, he was instrumental in bringing about the recent agreement between the I.A.S. and the A.H.S., which combined their management functions for a 2-year trial period.

Born in London, England, on May 15, 1888, Dr. Klemin received his Bachelor of Science degree from London University in 1907. He came to the United States in 1914 and received his Master of Science degree at the Massachusetts Institute of Technology in 1915. Dr. Klemin became a naturalized citizen in 1917, while serving as Head of the Aeronautics Department at M.I.T. He served as Officer-in-Charge of the Research Department, Army Air Service, at McCook Field, Dayton, Ohio, during World War I.

▸ **Designer**—Dr. Klemin was credited with designing, in 1921, the first amphibian landing gear used in the United States and was a winner of Army and Navy airplane design competitions.

In 1925, Dr. Klemin was named Guggenheim Research Professor of Aeronautics at N.Y.U. He was appointed to this newly established professorship at his own request so that he might devote his time to research and teaching rather than to administrative affairs.

▸ **Author**—He was author of *Textbook of Aeronautical Engineering*, *If You Want to Fly*, *Simplified Aerodynamics*, and *Airplane Stress Analysis*. His numerous technical articles appeared in many aeronautical periodicals, both

The late Dr. Alexander Klemin.

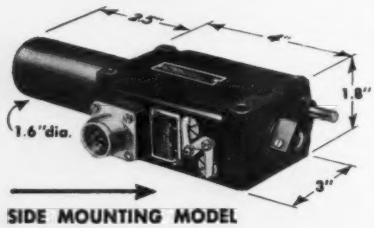
here and abroad. He was a contributor to the *Encyclopedia Britannica* and the *Encyclopedia Americana* and aeronautical editor for the *Scientific American* and Pitman Publishing Corporation. He was associated with *Aviation* magazine as Technical Editor from 1915 to 1917. For the past few years he had devoted part of his time to the compilation of a cyclopedia of aeronautical engineering. Dr. Klemin was also well known to I.A.S. members, through the pages of the AERONAUTICAL ENGINEERING REVIEW, for his lucid and stimulating reports on Technical Sessions of I.A.S. Annual Meetings and for his critical reviews of aeronautical books.

▸ **Consultant**—During his career, Dr. Klemin was consultant to the Bureau of Aeronautics, Navy Department; the U.S. Air Mail Service; the C.A.A.; and many aircraft manufacturers. He also served with the N.A.C.A. and was lecturer at the College of Engineering, Princeton University. Since his retirement from the Guggenheim School of Aeronautics in 1945, he had divided his time between consulting work and compiling his cyclopedia of aeronautical engineering.

Dr. Klemin is also a member of the following technical societies: the Royal Aeronautical Society, the American Society of Mechanical Engineers, and the Society of Automotive Engineers. He was a member of the Engineers and Wings clubs, New York.

Dr. Klemin is survived by his wife, the former Miss Ethel Murton, and a daughter, Miss Diana Klemin.

The New
Trim Trol®
ELECTRIC ROTARY ACTUATOR



SIDE MOUNTING MODEL

"LEADING EDGE" MODEL

★ Two Mounting Styles. Side mounting model for general purpose and "Leading Edge" mounting model for Trim-Tab applications. See above.
★ Compact Size. See dimensions above.
★ Weight 2.25 pounds.
★ Operating Load Capacity 350 in. lbs. (Std. Ratio)
★ Static Capacity 1500 in. lbs. minimum.
★ Zero Backlash Output Shaft.
★ Positive Overtravel Safety Stops.
★ Radio Noise Filter Built In.
★ Compliance with all applicable specifications.
★ POSITIONING CONTROL or electrical synchronizing available using our "Servosyn" unit.

★ Position Transmitter Potentiometer Built In and Externally Adjustable.

WRITE FOR BULLETIN 111

AIRBORNE
ACCESSORIES CORPORATION
25 MONTGOMERY ST. • HILLSIDE 5, NEW JERSEY
HOLLYWOOD, CAL. • DALLAS, TEX. • OTTAWA, CAN.

Institute of Brooklyn and Director of Aeronautical Research. For 7 years previous he was a member of the staff. Before going to Brooklyn, he had 2 years as Research Fellow in Aerodynamics with the Daniel Guggenheim Airship Institute, in Akron, 2 years as Research Fellow in Engineering Research at the University of Michigan, and 4 years with Whitman-Barnes, Inc., of Detroit. Dr. Harrington is well known in aeronautical circles for his numerous publications on various phases of aerodynamics, lectures before sectional and national societies, and frequent reviews of publications.

An Associate Fellow of the Royal Aeronautical Society, as well as of the Institute, Dr. Harrington has been active in I.A.S. affairs, serving on the Advisory Committee and on seven other committees.

Vaughan Named Director of Maintenance Firm

Guy W. Vaughan, A.M.I.A.S., former Chairman of the Board of Curtiss-Wright Corporation and Wright Aeronautical Corporation, has been elected a Director of Aircraft Maintenance International, Inc., which provides maintenance and overhaul service on a contract basis exclusively for air lines.

A long-term lease prepared by The Port of New York Authority calls for Aircraft Maintenance International to erect a permanent hangar on New York International Airport. Pending completion of the building, the company is servicing air lines in temporary facilities at New York International Airport and at its shops in Jamaica, N.Y.

Guy Vaughan, an aviation industry pioneer, is also a Director of the Manufacturers Trust Company and the T. E. Conklin Brass & Copper Company and is a Director and Member of the Executive Committee of the Western Electric Company, Inc.

Lederer Reappointed to N.A.C.A. Committee

Dr. Jerome C. Hunsaker, N.A.C.A. Chairman, has announced that Jerome Lederer, F.I.A.S., President of the Flight Safety Foundation, has been reappointed a member of the Committee on Operating Problems, technical subcommittee of the N.A.C.A.

The responsibilities of Mr. Lederer, who will serve in a personal and professional capacity without compensation, include: advising on operating problems, reviewing research in progress both at N.A.C.A. laboratories and at other organizations throughout the country, recommending research projects, and assisting in coordination of research programs.

Jerome Lederer was honored earlier this year with the award of a Special I.A.S. Council Certificate for his outstanding contributions to flight safety.

Errata

A photograph of Elmer R. Bayless, Field Service Representative, Wright Aeronautical Corporation, was erroneously published on page 10 of the March REVIEW instead of the photograph of Ralph L. Bayless, which is reproduced below. When the mistake was discovered, it was too late to substitute the correct photograph. Our apologies to all concerned.

Ralph L. Bayless.

Ralph L. Bayless, Chief, Preliminary Design, Consolidated Vultee Aircraft Corporation, is one of the two Western Area Representatives to the I.A.S. Council for 1950. C. P. Steele, Senior Group Engineer, Boeing Airplane Company, shares western representation with Ralph L. Bayless.

Stress Analysis Meeting Scheduled for May 25–27

The Society for Experimental Stress Analysis has announced that its Annual Spring Meeting will be held at the Hotel Statler, Cleveland, on May 25, 26, and 27.

Those interested in attending or participating in this Meeting may obtain full particulars by writing to the Society, P.O. Box 168, Cambridge 39, Mass.

A.S.E.E. to Hold Annual Meeting in Seattle on June 19–23

The University of Washington, Seattle, will be host to the 1950 Annual Meeting of the American Society

for Engineering Education, which will be held on June 19 to 23.

▸ **Aeronautical Laboratory**—The University of Washington's Department of Aeronautical Engineering will have open for inspection during the sessions its extensive laboratory facilities, which are used by both graduate and undergraduate students. Among the special equipment in the Department's laboratory are the 8- by 12-ft., 250-m.p.h. Kirsten aeronautical laboratory, a 1- by 2-in. continuous-flow closed-circuit supersonic wind tunnel, and a 3- by 3-in. open-circuit intermittent supersonic wind tunnel. The Department is also giving special emphasis to the accumulation of structural test specimens to demonstrate the relationship between theory and practice in structural analysis.

Other features of interest to engineers will be an exhibit of teaching aids contributed by universities and industry, a symposium on the teaching of art to engineering students, a discussion of human relations in industry, and a 4-day summer-school session on the integration of the teaching of English and humanistic-social studies with the teaching of engineering and science.

I.A.S. Newslines

▸ Honored . . . **Charles H. Colvin,** F.I.A.S., Vice-President, G. M. Giannini & Co., Inc., received the Stevens Institute of Technology honor award for "notable achievement" at 80th Annual Alumni Dinner in February. Mr. Colvin was cited for contributions in the design and manufacture of aeronautical instruments.

▸ Helioplane Contract . . . Helioplane, designed by **Otto C. Koppen,** F.I.A.S., M.I.T. Professor of Aeronautical Engineering, will be manufactured under contract by Aeronca Aircraft Corporation. Helio Aircraft Corporation, whose Chairman of the Board, Dr. Lynn Bollinger, set up craft's specifications, will build first four-place models at the Norwood, Mass., plant. Aeronca will produce components after C.A.A. certification, expected by July, and eventually will do complete assembly. License recently granted to Fairchild Engine and Airplane Corporation for use of Helioplane design features does not include manufacture of light personal-type aircraft.

▸ Department Chairman . . . **Leslie R. Parkinson,** A.F.I.A.S., formerly in charge of the aeronautics option at Syracuse University, has been appointed Chairman of the Department of Mechanical Engineering, L. C. Smith College of Applied Science, Syracuse University.

▸ Coral Sea Post . . . **Captain Frederick M. Trapnell,** U.S.N., A.F.I.A.S., has been assigned command of the U.S.S. "Coral Sea," one of the three largest aircraft carriers. Captain Trapnell, winner of The Octave Chanute Award for 1949, was formerly Commander of the Naval Air Test Center at Patuxent River, Md.

▸ Design for Research . . . **Carl J. Wenzinger,** A.F.I.A.S., has been appointed Chief of the Aerodynamics Department of Sverdrup & Parcel, consulting engineers of St. Louis, Mo. He is connected with projects relating to the design and development of various supersonic test facilities for the new Air Engineering Development Center of the U.S.A.F. Mr. Wenzinger was formerly Chief, New Design, Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation.

▸ Sales Manager . . . **J. E. "Gene" Winchester,** A.F.I.A.S., has been named Sales Manager for Curtiss-Wright Corporation's Airplane Division at Columbus, Ohio. He started with Curtiss-Wright in 1938 as a Design Engineer, served for 1½ years as Chief Engineer of Slick Airways, Inc., and rejoined Curtiss-Wright in July, 1947, as a Member of the Engineering Sales Staff.

Corporate Member News

• New Division . . . **Aluminum Company of America** is forming a new division at its New Kensington, Pa., works for the rolling of magnesium sheet to answer increased demand for magnesium in airplane construction and other phases of national security program. Alcoa's magnesium rolling operations were discontinued in 1947 following sharp postwar drop in demand for magnesium sheet.

• Profit . . . **American Airlines, Inc.,** has reported 1949 profit of $6,511,237, after Federal income taxes of $1,800,000. A "carry-forward" credit of $950,000 reduced the amount of taxes payable. In 1948 there was a loss of $2,893,671. Total revenues were $103,000,000, the highest in the history of the company. Passenger traffic was 15 per cent higher than in 1948; 33,000,000 ton-miles of air freight were flown in 1949—42 per cent above the 1948 figure and double the tonnage of 1947.

• Maintains Safety . . . At the end of 1949, **American Overseas Airlines, Inc.,** maintained its high safety record by completing the third year without fatality to passenger or crew member. For 1949, income from passengers, express, and foreign and U.S. mail increased over 1948. There were, however, substantial reductions in income arising from charter operations conducted in 1948, to, from, and within Germany. Expenses for 1949 were $1,218,798 above 1948, arising principally from the operation of larger aircraft. The company reported a net operating loss of $348,477 for 1949, after subtraction of a Federal income tax credit of $240,000. In 1948, a profit of $991,174, after taxes, was realized.

• Parts Contract . . . U.S.A.F. has awarded a contract to **Beech Aircraft Corporation** for $1,500,000 worth of aircraft service parts for twin-engined Beechcrafts in serv-

DE LUXE NAVION

Ryan Navion De Luxe 205 for 1950 features important refinements: manually controlled engine cowl flaps as standard equipment; cylinder head temperature gage; flexible hose to replace rigid plumbing to flap and nose-gear actuating cylinders; fin-to-elevator radio antennas; and improved cabin air exit arrangement.

FOR CAA SAFETY AT OXYGEN ALTITUDES

OHIO

OXYGEN MASKS

These exceptionally efficient and comfortable new masks have been developed by the makers of the first true aviation oxygen masks in co-operation with the nation's top aero-medical experts.

Unique valve and rebreathing system gives greater oxygen economy at all altitudes. Amazingly lightweight, streamlined design gives freedom of vision and movement, conforms to facial contours for a close yet surprisingly comfortable fit. Specially formulated Arctic latex stays flexible even at 65° below zero.

B-L-B—Nasal Mask (above) leaves mouth free for talking or eating.

B-L-B — Oronasal Mask covers nose and mouth for greatest efficiency.

A-8B — for continuous flow systems.

A-14 — (at right) for greatest oxygen economy with demand-type systems. Effective with or without helmet.

For informative drawings, specifications and prices, write

OHIO CHEMICAL & SURGICAL EQUIPMENT CO.
A Division of Air Reduction Company, Incorporated
Aviation Equipment Dept., Cleveland 14, Ohio

Equipment on the Douglas Skyrocket includes the Giannini Adiabatic Temperature Probe for the measurement and indication of stagnation temperatures. This probe is available with a selection of temperature sensing elements in accordance with the available equipment and sensitivity desired. This selection includes thermocouple, resistance and special supersensitive resistance type elements. Recovery characteristics, as well as aerodynamic design, are excellent. Weight — .4 lb.

For detailed information concerning the Temperature Probe, write to G. M. Giannini & Co., Inc., 254 W. Colorado, Pasadena 1, Cal. or 697 Morris Turnpike, Springfield, N. J.

G.M. Giannini & CO. INC

ice of U.S.A.F., A.F. Reserve, and Air National Guard. Deliveries are scheduled from April to August.

• B-47A Completed . . . First production model of U.S.A.F. B-47A Stratojet was completed on March 1 by **Boeing Airplane Company,** Wichita, and turned over to A.F. Aircraft Engineering Inspection Board. Almost identical to the XB-47 in appearance, the swept-wing B-47A has six G-E J-47 engines of 5,200 lbs. thrust each, additional fuel capacity, and internal improvements resulting from XB-47 flight tests. B-47A was completed less than 18 months after U.S.A.F. go-ahead on quantity production . . . New Boeing electrical laboratory, described as most complete of its type in the entire industry, is cutting down to zero actual airplane flight-test time required to prove electrical systems. Almost all testing of new airplane's electrical systems, generators, alternators, motors, switches, and wiring can be done as a complete unit before construction of airplane. B-47A Stratojet system has already been tested in new laboratory. Three 500-hp. gasoline engines provide up to a maximum of 840 kw. in various currents and voltages. Use of 120-volt d.c. system for aircraft is being investigated for U.S.A.F. at present.

• Turboprop Seaplane . . . Four-engined XP5Y-1 flying boat, manufactured by **Consolidated Vultee Aircraft Corporation,** made successful taxi run on San Diego Bay during first week of March. Hydrodynamic research by U.S. Navy and Convair have resulted in use of high length-to-beam ratio hull and cruiser bow. Four Allison T40 engines, driving contrarotating propellers, develop 22,000 shaft hp. Weight is over 60 tons. Craft will be used for long-range search-rescue and antisubmarine warfare missions.

• Marine Packet . . . **Fairchild Aircraft Division** of Fairchild Engine and Airplane Corporation delivered the first of a number of R4Q-1 Packets to the U.S. Marine Corps Air Station at Cherry Point, N.C., on February 27. Marines will use the R4Q-1's (Navy designation of the C-119) for normal air logistical support to aviation and ground units . . . Air Force and Navy are using Fairchild Mobile Training Units to familiarize personnel with systems of the C-119 Packets. Mock-ups of actual operational equipment mounted on compact panels are flown to military bases at least 30 days before airplanes are to be received so that personnel will be familiar with aircraft's operating details and maintenance when craft do arrive.

• Goodyear Honored . . . P. W. Litchfield, President of **Goodyear Aircraft Corporation,** has received a plaque citing the firm for perfecting cross-wind landing wheels for airplanes. Presentation was made by J. J. Carmichael, President of Capital Airlines, whose installation of cross-wind wheels on three new Super DC-3's makes it the first U.S. commercial line to adopt the improvement. The Goodyear device permits large planes to land and take off on single-runway fields and aids large air liners in using single-runway airfields closer to the center of a big city.

• New Radios . . . **Lear, Inc.,** has announced new equipment for personal air-

NEW TESTING EQUIPMENT

Strain Gages, etc.

Scanning Units up to 72 gages per second.

X-Y Recorders 12 to 48 Channels.

Heiland Oscillographs.

Universal & Special Testing Machines up to 1,000,000 pds.

Photoelastic Machines.

YOUNG TESTING MACHINE CO.
BRYN MAWR, PA.

AIRSURANCE
Airline Passenger Insurance

Annual Policies
from $5,000 to $100,000
at new low rates

No Physical Examination • No Age Limit

EXAMPLE
$25,000.00 for death or dismemberment
$1,000.00 for Hospital and Doctor's bills
$50.00 per week when disabled
PREMIUM $38.00 per year

Policies cover all airlines in U. S. and American Flag lines world-wide — also airlines in Canada, Mexico and South America which meet safe operating standards.

Backed by the Combined Assets of
Aetna Casualty & Surety Co.
American Surety Co. of N. Y.
Century Indemnity Company
Hartford Accident & Indemnity Co.
Maryland Casualty Co.
Massachusetts Bonding & Insurance Co.
New Amsterdam Casualty Co.
Standard Accident Insurance Company
Travelers Indemnity Co.
United States Fidelity & Guaranty Co.

U.S. GROUP

WRITE OR PHONE ANY U. S. GROUP OFFICE

UNITED STATES AVIATION UNDERWRITERS
INCORPORATED
80 JOHN ST. • NEW YORK 7, N. Y.
WASHINGTON ATLANTA CHICAGO LOS ANGELES

craft: the "Panellete"-type V.H.F. transmitter and the 1950 Learavian portable radio. The "Panellete" Model RT-10CP is a six-frequency V.H.F. transmitter with an output of 2 watts. Weighing 10 oz., it occupies a $1^{11}/_{16}$-sq.in. space on the instrument panel. The Learavian is a portable three-way (110 volts d.c., a.c., or battery-operated) receiver covering the marine, standard broadcast, and airways bands. It has built-in loop antenna suitable for direction finding, connector for external antenna, headphone jacks, and dynamic speaker . . . Operations of the company during 1949 resulted in a net profit of $510,469.59 on sales of $7,368,000. In 1948, sales amounted to $5,326,000. For the first 2 months of 1950, sales of $1,300,000 have been reported; backlog of unfilled orders at end of February was $8,750,000.

• Martin Earnings . . . Net profit of $5,131,500 realized in 1949 by **The Glenn L. Martin Company** marked a significant gain over the operations of the 2 previous years, when sizable net losses were reported. These earnings, largest since 1945, were realized despite a decline in sales deliveries to near $52,000,000 from above $72,000,000 in 1948. Gain is attributed primarily to fact that no further commercial model inventory write-offs were required in 1949; to satisfactory performance under military contracts, and to increasingly closer controls over operational costs and expenses.

• B-25 Trainer . . . **North American Aviation, Inc.,** has proposed modification of World War II B-25 Billy Mitchell bombers into pilot trainers, personnel transports, and navigation and radar trainers. B-25J prototype pilot trainer is touring U.S. to acquaint Air Force personnel with performance and characteristics. Principal structural change in the basic airplane is enlargement and lengthening of fuselage nose section to provide more cockpit space and additional seats. Five may be seated in the pilot trainer, ten in the transport, and seven in the radar bombing and navigation trainers. Any of six different engine sizes, P. & W. or Wright, may be used in the trainers . . . New jet interceptor for the U.S.A.F. is the North American F-95A, formerly designated the YF-86D, which is a higher flying and speedier version of the F-86 Sabre, official holder of the world's speed record. The F-95A features a "shark nose," which houses special radar equipment for all-weather flying.

• Aerobee Components . . . **Ryan Aeronautical Company** has announced that the company has been building most of the assemblies for the 3,000-m.p.h. Aerobee high-altitude sounding rocket, except the propulsion unit and fuel tank. Now to be used by the U.S.A.F. for upper atmosphere research, the two-stage liquid-fueled Aerobee was developed originally for Navy Bureau of Ordnance by Aerojet Engineering Corporation, from which Ryan has received its contracts for manufacture of components . . . New contracts received by Ryan total approximately $2,000,000: C-97A aft fuelage sections, cargo doors, and all the floor beams for other cargo planes for Boeing Airplane Company, $750,000; external wing tanks for an undisclosed contractor, $750,000; jet engine components for General Electric Company, $250,000; and exhaust manifold systems for the U.S.A.F., $250,000 . . . Earnings for 1949 were $358,052, as compared with $356,603 for 1948. Investment in new equipment during 1949 totaled $406,054.

• Faster Fueling . . . An improved aircraft refueling truck has been put into operation by **Shell Oil Company** and is now in use at Charlotte, N.C., servicing Eastern Air Lines' Constellations. Others are under construction for Shell use in other parts of the country. New refueler has two independent hose systems, each having a pumping capacity of more than 200 gal. per min., as compared with conventional rate of 75 gal. per min. Use of two axles instead of three or four increases maneuverability of truck despite large tank capacity. Jet eductor system designed by Shell as part of valving equipment provides suction to collapse hose when it is not in use, thus permitting easier and quicker handling. Unit can also be employed to evacuate gasoline from aircraft tanks to allow correct distribution of pay load.

• Flight Engineers' Helper . . . Boost in U.S.A.F. bomber ranges is expected by use of electronic analyzers, 45 of which have just been ordered by the Air Materiel Command from **Sperry Gyroscope Company.** Total amount of contract for the analyzers, which are to be used by the U.S.A.F. Strategic Air Command, is approximately $750,000. U.S.A.F. will service-test them on a large scale to determine their value in combat missions. The analyzer, heretofore used principally as an electronic in-flight trouble shooter on scheduled air lines, will be evaluated both as a flight instrument for cruise control and as a maintenance tool to streamline trouble shooting at reduced cost . . . Air Force has also awarded contracts to Sperry for 1,200 Gyrosyn compasses and a quantity of other Gyrosyn indicators, 714 directional gyros, and 595 vertical gyros. Value of orders is over $2,500,000.

• Sales Record . . . Shipments of **Thompson Products, Inc.,** to aircraft customers during 1949 were approximately 36 per cent higher than in 1948, with production for jet-powered planes representing a large portion of total aircraft business. Net sales for the year reached a new peacetime record, and net profits were the highest in the company's history. Net sales totaled $107,608,803 and net profit, $6,014,748, after all charges and Federal taxes.

• New York–Paris Teletype . . . Direct communication over the first radio-teletype circuit ever operated between New York and Paris for an individual U.S. commercial air line was recently opened by **Trans World Airline.** All overseas messages, from any airport served by T.W.A. on its domestic routes, are sent via teletype to its La Guardia routing center, radio-teletyped to Paris, and relayed by manual radio telegraph or radio-teletype to cities in Europe, Near East, or Mediterranean area.

• More Cyclones . . . Orders amounting to approximately $3,000,000 for Cyclone engines have been received recently by **Wright Aeronautical Corporation.** These orders are in addition to previous contracts with the military and private air lines for engines of the same type. The bulk of the engines are 800-hp. Cyclone 7's, which will power the North American T-28 high-performance trainers. Orders included 1,425-hp. Cyclone 9's for the Grumman SA-16 Albatross rescue, utility, and hospital amphibian and 2,500-hp. Cyclone 18BD engines for Lockheed Constellation passenger transports operated by commercial air lines. Deliveries will be made in late 1950 and early 1951.

Meet Your Section Chairman

Dwight H. Bennett

San Diego Section

An aerodynamics engineer at Consolidated Vultee Aircraft Corporation, San Diego Division, Dwight Bennett is a graduate of California Institute of Technology, class of 1940. On leaving California Institute of Technology, Mr. Bennett was employed in the Aerodynamics Section of Engineering at Consolidated Aircraft Corporation in San Diego.

▸ **Directed Flight Tests**—During, and immediately after, World War II, he served as Chief Flight Test Engineer and Chief Flight Research Engineer for the company. In this position, he was responsible for the development of flight-test methods and procedures, flight-test instrumentation, and engineering flight-test reports.

Later, as an aerodynamics engineer for Consolidated Vultee, Dwight Bennett was responsible for the setting up of airflow calibration and data reduction procedures used in operation of Consolidated Vultee Aircraft Corporation's wind tunnel at San Diego. Since that time, he has been project aerodynamicist on a development project.

Mr. Bennett has been active in I.A.S. affairs in the San Diego Section for several years, serving as a Section officer or member of the Executive Committee throughout the period of planning and construction of the new I.A.S. Building in San Diego.

He is a native of Oklahoma, is married, and has three children. His favorite sports, when time is available, are tennis and bowling.

ENGINEERS NOTEBOOK
EFFICIENT COUPLING OF BEADED AIR HEATER JOINT
MARMAN CHANNEL-BAND COUPLING WITH MOULDED SLEEVE PROVIDES AN IDEAL JOINT IN AIRCRAFT INSTRUMENT PANEL HEATER. DIFFERENT SLEEVE LINERS AVAILABLE FOR THIS COUPLING TO COVER A WIDE RANGE OF TEMPERATURE AND PRESSURE REQUIREMENTS.
TO CLAMP SYNTHETIC RUBBER TUBE TO BEADED DUCT
MARMAN UNIVERSAL CLAMPS CONNECT FLEXIBLE DRAINAGE TUBE TO STAINLESS STEEL OUTLET. CLAMP ESPECIALLY RECOMMENDED FOR INSTALLATIONS WHERE HEAVY VIBRATION, IRREGULAR SHAPE AND CORROSION ARE FACTORS.
SUPPORTING ELECTRIC AND HYDRAULIC LINES
MARMAN T-BOLT CLAMP USED IN CONJUNCTION WITH HARNESS CLIP AND BRACKET PROVIDES EFFICIENT MEANS TO ATTACH ELECTRICAL AND HYDRAULIC LINES TO LANDING GEAR STRUT. THIS ASSEMBLY PROVIDES HIGH SECURITY AGAINST VIBRATION WITH MINIMUM COMPLEXITY.
THE BEST CLAMPS, STRAPS AND COUPLINGS
MARMAN PRODUCTS CO. INC.
940 W. FLORENCE AVENUE
INGLEWOOD, CALIFORNIA

I.A.S. Sections

Baltimore Section

Welcome W. Bender, *Secretary*

Captain Walter S. Diehl, U.S.N., F.I.A.S., spoke on "Problems in the Administration of Research" at the February 16 meeting held at The Johns Hopkins University. He is in the office of the Assistant Chief for Research and Development, Bureau of Aeronautics.

Captain Diehl stated that successful research represents a return on an investment provided that certain fundamental concepts of administration are realized. Research must be timely, with a well-balanced application. Careful consideration must be given to (1) the research program, (2) facilities for conducting the research, (3) personnel employed, and (4) funds available.

▶ **Research Personnel**—The speaker considered the personnel more important than the facilities. He covered problems arising from the administration of research personnel, such as individual temperaments, restlessness on the job, incentives offered the research engineer, recognition for a job well done, and adequate pay for achievement. Captain Diehl cited the small number of college graduates suited for research work, in particular, the lack of young men possessing what he called "intelligent curiosity."

He mentioned the excellent findings resulting from small laboratories contrasted to the large laboratories that are generally saddled with red tape. In closing, Captain Diehl stated that the best way to stifle research is to promote the real research men to higher paid positions where administrative duties take all their time and energies.

Chicago Section

Alfred F. Stott, *Secretary*

The meeting of March 7 got off to a start with 35 members assembling for dinner at the Illinois Institute of Technology. "The Airplane and People" was the topic of a talk given by Wolfgang Langewiesche, Research Pilot, Kollsman Instrument Division, Square D Company. Seventy-two members attended the lecture meeting, which was presided over by Harold V. Hawkins, Section Chairman.

▶ **Flight Principles**—Mr. Langewiesche showed that through the years the airplane and its pilot have not been a particularly happy pair. Since the natural instinct of people cannot be changed, designers and engineers must

effect a change in their products if the aircraft industry and private flying are going to advance to the desired stage. He pointed out that several basic flight principles are not easily grasped by trainees, which may give rise to some of the troubles that pilots are faced with and which sometimes lead to accidents.

Many serious flight problems, such as the effect of torque, stability, adverse yaw, and ground looping, were discussed. Mr. Langewiesche stated that, although we normally think of an airplane as having too many controls, each of which perform multiple functions, more controls might be desirable if each did only one job. Instrument problems were also examined. A question-and-answer period followed the talk.

Hagerstown Section

Logan T. Waterman, *Secretary*

D. W. Weller was Chairman of the meeting held on January 17 in the Loyal Order of Moose Hall. Fifty persons attended. Guest speaker was Albert W. Gabriel, Jr., of Westinghouse Electric Corporation, who spoke on "Turbojet Installation Problems."

▸ **Turbojet Complexity**—Mr. Gabriel opened his talk by comparing the ease of installation of the first simple turbojets with the situation today, where engines have become more complex and installation problems have thus increased. He discussed the problems of positioning the engine in the pod, wing, or fuselage; of mounting the engine in position, the basic method of which is called the three-point system; of installing of the fuel system; of control installation; of instrumentation; and of cooling.

▸ **Affects Design**—The turbojet has had a great effect on airplane design. Because of the absence of a propeller of large diameter, the landing gear is short. The low squatting airplane makes service and maintenance an easy item. The absence of an engine of large diameter allows the frontal area to be reduced to that required by the pilot. The guns in a military airplane can be grouped in the nose for more effective fire control. The pilot can be moved farther forward, and greater visibility can be achieved.

Los Angeles Section

H. A. Storms, *Secretary*

A meeting was held on January 19 with Section Chairman P. A. Colman, of Lockheed Aircraft Corporation, presiding. Approximately 400 members and guests attended.

▸ **Rocket Research**—The speaker of the evening, Dr. Hsue-Shen Tsien, Goddard Professor of Jet Propulsion, California Institute of Technology, was introduced by Harold Luskin, of Douglas Aircraft Company, Inc. He chose as his topic "Research in Rocket and Jet Propulsion."

Dr. Tsien emphasized two prominent features of rocket and jet engineering: the short duration of power-plant operation and the extreme intensity of reaction in the motor. Advantages are gained by operating these engines (rocket and ram-jet) at high thrust initially and thus accelerating the vehicle to high speed, while the kinetic energy at the end of the power-plant "burning time" can be utilized to achieve range by coasting.

By realizing that the duration of flight of missiles is a matter of minutes instead of thousands of hours, materials can be stressed for ultimate strength and not for creep. For example, if the part is designed to have a life of only a few minutes, it can be stressed approximately six times higher.

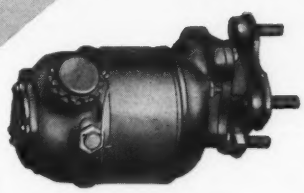
▸ **Cooling**—Heat flux at the throat of a rocket nozzle has been observed

(*Continued on page 78*)

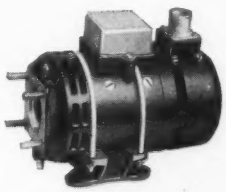
Check These 6 Advantages of Redesigning Your Product with a...

Lamb Electric

SPECIAL APPLICATION MOTOR



Sturdy and reliable, explosion proof construction, helical geared fuel transfer pump motor.



Aircraft hydraulic pump motor with maximum output, minimum weight. Adaptable to many heavy-duty industrial applications.

By using Lamb Electric *motor parts* or a complete *frame motor* —engineered for the *exact* requirements of your application—you may gain these advantages:

IN THE MOTOR—

1. Reduced cost, weight, space.
2. Exact mechanical and electrical characteristics.
3. Thorough dependability.

IN THE PRODUCT—

4. Better performance.
5. Improved eye-appeal.
6. Compactness, less weight.

Our engineering department will be glad to team up with yours to help achieve these results. *The Lamb Electric Company, Kent, Ohio.*

They're Going Into America's *Finest* Products

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

Captain F. M. Trapnell, U.S.N., Commander, Naval Air Test Center, U.S. Naval Air Station, Patuxent River, Maryland. (Now Commander, U.S.S. "Coral Sea.")

A Test Pilot Looks at the Jets

Speech given at

Luncheon, Fifth Annual Flight Propulsion Meeting
Cleveland, Ohio, March 24, 1950

"THE FIRST JET FIGHTER in the U.S. became available in 1942, shrouded in the most intense secrecy. I was fortunate enough to fly it in the early stages. Like most pilots, I had heard and read some of the information on jet propulsion, but in the abstract, it seemed a weird impractical means of propelling an aircraft. It was too much like arranging two small propellers internally, in tandem, and building a fire between them. Consequently, it was an intensely interesting experience to fly one for the first time. After observing ground operation and being duly impressed by the temperatures involved, the terrific tip speeds, and the fierce roaring exhaust, it was a revelation to discover that, from the pilot's position, the engine at full power was dead silent and vibrationless. During the take-off run, you could hear the landing gear rattling; it was a unique and rather pleasant sensation. While you wondered, instinctively, how such things could be, the machine floated gently into the air and began a sort of a climb. It was an actual fact—but, amidst such ominous quiet, it wasn't convincing to an aviator who had gone deaf listening with gratitude to all the din and fuss of the old reciprocating engine and propeller.

"We have, of course, gotten used to jets—but I don't think they have fully restored my hearing yet. Five or 6 years later, recently, I flew this same old prototype again. It seemed much more of an antique than contemporary piston-engined types. From the pilots' point of view, some wonderful things have been accomplished in the few years of development of jet aircraft. Of course they ought to be wonderful with the price tag they have on them!

"In undertaking a discussion of piloting problems, the first things that come to my mind are the 'piloting pleasures' on jet aircraft. It is, of course, well known that all of our pilots want so badly to fly jet aircraft that they practically have inferiority complexes until they do. But we still have few jet aircraft; they are still expensive to operate; they cannot entirely replace the piston engine; unfortunately, they can't even tax the pilot's patience or endurance, which the older ones can to a prodigious extent. Consequently, we have to refuse large numbers of requests to make check-out or familiarization flights in jets, with the assurance that they are actually easier to fly and that the most significant parts of the transition are to be made on the ground.

"There is a great deal of glamorized foolishness written about jets and jet pilots for public consumption. It probably does no real harm except to irritate some of their less starry-eyed compatriots. In this connection, I wish I could read to you a feature article from the *Saturday Evening Post* entitled 'Jet Guys are Different,' covering, in intimate detail, life in the first Navy Jet Fighter Squadron—in the air, on the ground, and at home. But at the same time you should read a parody on it, written by a guy condemned to duty in a squadron of obsolete Avengers, entitled 'Turkey Pilots Are Normal.' Nevertheless, if we are to obtain the maximum overall performance and tactical value out of a jet aircraft, the pilot must exercise more judgment than is required under similar circumstances in propeller aircraft. This means that he must have somewhat more advanced training, largely in matters of simple basic theory, and he must think more. It is a fact that propeller-driven aircraft are operated successfully in many cases on a rather large measure of misunderstanding—rules of thumb, 'old-wives-tales,' 'seat-of-the-pants' im-

---

EDITOR'S NOTE: Captain Trapnell's remarks were so full of interest to all I.A.S. Members that we reproduce them in full in lieu of our usual Editorial.

pulses, and simple direct observations and habits. They will perform amazing things in an emergency. For instance, anybody knows that an airplane will not fly with its wings folded. Nevertheless, a young pilot succeeded, last year, in taking off a Douglas Skyraider with the wings folded and in gaining 250 ft. of altitude before he crashed—without killing himself. No jet would do it—and no jet pilot should try.

"The type of judgment wanted in jet pilots—in obtaining maximum aircraft performance, in maneuvering most effectively, and in contending with weather problems—requires experience. I do not believe that it is profitable to attempt to provide this experience in jet aircraft because they are too expensive to operate. I believe that a limited amount of time and money spent on propeller-driven aircraft will provide more and better experience, in the basic phase, than if it were spent on jet aircraft. This is certainly true with respect to flying the weather; you can't learn about weather without getting into it—and a jet is no place to begin the process of getting into it. At some time, considerably in the future, it may be profitable to give basic training in jets.

"The other day we lost a high-powered jet fighter in the following way. The pilot was experienced but was not familiar with the type. He made a normal take-off with flaps extended and retracted them at the proper time. At this point he did not change the longitudinal attitude of the airplane, and he found himself sinking. He decided that 'something' was wrong and that he would not clear obstacles ahead, so he cut the throttles and landed—and ran off the runway. His mistake lay in failing to appreciate the 'apparent' change in angle of attack, at constant lift, between the flap-down and flap-up conditions. This change requires that the nose be raised sharply as the flaps come up if a constant climbing flight path is to be maintained. The process may be somewhat more striking in jets than in propeller aircraft for several reasons. In the first place we habitually take jets off with flaps extended in order that the landing gear may be retracted at the lowest possible air speed and as early as possible. The necessity for gaining air speed after take-off is more urgent because of the thrust-speed-power relationship, and the pilot is more reluctant to pull the nose up at this point—instinctively but incorrectly fearing that he will *reduce* his air speed in so doing. Many pilots complain of this characteristic 'sinking' at this particular point after take-off without understanding the attitude and angle of attack variations that must occur and without realizing that all of our jet airplanes do have adequate power to continue climbing during the process. This is a rather crude example of the type of understanding that is required and which is more critical in jets, because it explains procedures that are in conflict with the pilot's impulses. As another example, the characteristic variation of power-available, directly with speed at constant thrust, must be clearly understood, particularly in contrast to the situation that prevails in propeller aircraft. It is, of course, the outstanding factor in jet performance. It produces comparatively poor take-off, it requires that much higher air speeds be employed for best climb, and it produces the tremendous increment in maximum speeds. These effects can be simply explained, but a pilot engaged in competitive combat maneuvers must bear in mind some less obvious effects. Combat performance requires that total energy, kinetic plus potential, be stored at as high a rate as possible or be maintained at as high a level as possible. The propeller aircraft stores energy most rapidly while climbing at its best climbing speed, a speed that is not far above the stall; consequently, it is logical for the pilot to convert kinetic to potential energy by 'zooming' and pulling the air speed down during maneuvers; it is not likely that he will reduce it so far that the energy-storing rate is seriously lowered.

"The situation in the jet aircraft is totally different. The speed for best climb is a long way above the stall. The pilot still has a strong tendency to pull the air speed down during maneuvers, converting kinetic energy into altitude, but, when he does, he suffers a great loss of power at constant thrust and a direct reduction of energy-storing rate. All of his previously acquired habits tend to involve him in this situation; it may actually be desirable in order to gain some momentary objective, but a few seconds later he will find himself at a serious disadvantage. The answer is a clear grasp of the jet power relationships and of the energy concept of airplane performance.

"The high climbing air speeds of jet aircraft have brought new emphasis to this concept, which holds that the altitude of an aircraft is significant only if the speed is also stated. It can be shown that a jet, but not a propeller aircraft, during its best climb, may actually store energy at a higher rate by momentarily leveling off instead of continuing a smooth climb. This results, of course, from the greater power available at the higher speed and lower altitude, but the process cannot be carried far because of the drag increase. It may not even be practical or profitable in execution, but it does tend to explain the observed fact that in jets the rate of climb is not critical to climbing speeds or to irregularities therein, provided they are kept on the high side.

"Another thing that pilots have observed in jets while flying formation and which has puzzled a good many is that, in the lower or middle speed range encountered in slow cruise at high altitude, the plane seems to fly at different speeds in level flight without any change in engine power setting. This is clearly explained by reference to the power-available and power-required curves for a typical jet aircraft. In the speed range for minimum throttle setting, which occurs at a much higher speed than that to which we are accustomed with the propeller, the intercept of these two curves is extremely flat. In other words, the power available at constant throttle setting varies with the speed, as does the power required, in nearly the same ratio at this part of the range.

"At the low end of the speed range and down to the stall, all airplanes require increasing power with de-

Scene at the Luncheon, March 24, 1950.

creasing speed. This produces a sort of power-setting instability that makes it impossible to continue level flight at fixed throttle setting. It is normally not noticeable in propeller-driven aircraft; but in jet aircraft the range of speeds involved is much greater, and the effects may be pronounced at high altitude. The pilot notes that his air speed is low and that he is losing altitude; he cannot regain level flight or climb until he has sacrificed considerably more altitude to build up the air speed. It is well that he understand the situation clearly. All these factors emphasize the necessity of keeping the air speed high if maximum jet performance is to be obtained, whereas in propeller aircraft if the pilot found himself with any such high speed and no momentary objective, it would be profitable to convert it immediately into altitude.

"The 'power-available' characteristics mentioned above inevitably tend toward poor take-off and climb characteristics, and they definitely limit the steepness of the climbing flight path. If the take-off does happen to be good, we will simply load the plane up with more fuel—because it's worth it. However, in naval carrier aircraft we have to stay within definite take-off and landing limits. The performance in this respect must be reasonably good, and we must maintain rather moderate values of wing loading and power loading. Fortunately for us, when you meet these requirements, you almost automatically provide good climb and high-altitude characteristics. The climbing performance of some of our late jet fighters is as good as the piston-engine fighters, and, of course, their performance at altitude is vastly better.

We may expect the pilot to understand and think more in jets, but we cannot reasonably expect him to withstand any greater physical demands. Consequently, many refinements are provided which are characteristic of jets but not necessarily so. The net result is that he is, in general, more comfortable in modern jets than he ever was before, provided everything works right, in spite of the increased speeds and altitudes.

"The most important element in this respect is the pressure cabin, which is a great blessing to the pilot at any altitude above 25,000 ft. and is essential above 40,000 ft. We have operated at altitudes of 40,000 to 43,000 ft. without this feature, but it is a disagreeable and uncertain business. Past policy has limited cabin pressures in fighters to those that produce a potential ratio of gaseous expansion of 2.3, because of the danger of explosive decompression. We are told that if the canopy is shot away under pressure there is likelihood that the pilot will blow his lungs out into his oxygen mask. From the pilots' point of view, higher cabin pressures would be desirable in routine operations, and such pressures will be provided with a selective reducing feature for combat. Under the present schedule, when the airplane is at 50,000 ft. the cabin altitude will indicate about 41,000, provided the engines are running normally. The pilot would be happier and more comfortable if he could be kept down to 30,000 ft. in the cockpit.

"Next in importance is the air-conditioning system that provides either automatic or manual temperature regulation. These systems are still rather temperamental, but they are generally effective. The problem is to improve their regulation characteristics and dependability or, perhaps, to learn their idiosyncrasies. One of the most important and difficult functions of air conditioning is to prevent frosting of the canopy, windshield, and instrument faces. Much more engineering experience and trial-and-error tests will be required be-

fore they become fully effective in this respect. The best of them still fall short under severe conditions, such as rapid descent into high-humidity regions.

"Antiblackout suits are provided for pilots in jet fighters, and they are effective. The need for them varies about as the square of the speed, because, although the permissible accelerations are no greater than in slower aircraft, the duration of these accelerations is much greater, and duration is as important as the amount of acceleration in its effect on the human system. The pilot can withstand 10*g* or 15*g* momentarily without ill effects, but even 4*g* sustained for a period of 8 or 10 sec. may black him out. For instance, if he is in a high-speed glide, indicating perhaps 400 knots, and pulls into a hard turn or pull-up to 5*g*, by the time he has curved the flight path through 90° his vision will have passed through a condition of gray fog to one of dark obscurity. By the time he has turned 180° at this acceleration he will be unable to hear. Naturally, he is uncomfortable but he is not unconscious. Under the pressure applied to the legs and abdomen by the antiblackout suit, the threshold at which these effects appear is considerably raised. It is worthy of note, however, that these conditions cannot be created at high altitudes because the wing lift and accelerations cannot be developed.

"However, not all of his modern equipment contributes to his comfort. Crash helmets have proved to be a necessary safety precaution due principally to potential effects of canopy failures at high speed and only secondarily to buffet in rough air. But these hard hats are heavy and become uncomfortable with time and under acceleration. The greatest nuisance are the various radio, oxygen, and *g*-suit connections. Although combined in various ways, with quick-disconnect attachments, they tug uncomfortably, particularly on the oxygen mask, and inhibit the typical swivel-necked fighter pilot from looking around with the facility that he should have.

"Certain other airplane characteristics are worthy of mention as they affect the piloting problem. For instance, the maneuverability of a fighter consists largely of its ability to roll fast, and light aileron forces are a prime requisite in what is considered to be a 'nice flying airplane.' The old aerodynamic balances became totally inadequate for the speed ranges now prevailing, and the aileron power boost system has become standard. With the elimination of balance surface, ailerons have become far more effective than they were before, and the stick forces still can be made as light and smooth as desired. As a result, our standards of rolling performance are now far above anything we dreamed of some years ago. Some of the present models at high speed may be rolled so rapidly as to do considerable violence to the pilot's sensibilities, without exceeding structural strength limitations. The low speed rate of roll has improved correspondingly to the great benefit of such evolutions as carrier approach, where it means greatly improved control at the minimum possible flying speed.

"Another external feature, prominent in the pilot's thinking, is the brakes. The term 'speed brakes' is redundant, and 'dive brakes' is unduly restrictive in implication. Whatever they are, brakes are an absolute necessity in a low-drag airplane operating at high altitude, and they are extremely valuable at all other times. For this reason they are standard in jets now, though they vary widely in effectiveness and in smoothness. They frequently cause undesirable buffeting and trim changes, being no more than deliberately created parasite drag. Cut-and-try modifications are often necessary to make them satisfactory. The best brakes will hold the air speed down sufficiently so that an extremely steep dive may be started from 40,000 ft. and continued to a low altitude without the attainment of dangerously high speeds. Without them it is impossible to make a shallow glide with the airplane at a high altitude without reaching speeds in the critical Mach Number range, particularly with the large amount of residual thrust characteristic of idling jet engines at altitude. The brakes are also useful in various tactical situations, such as gunnery runs and formation flying, as a means of controlling the speed. A thumb switch on the throttle usually permits the pilot to operate the brakes without moving his left hand, and he finds it a convenient and reassuring arrangement.

"With all the foregoing facilities, the pilot of a modern jet fighter may function effectively, provided everything works properly. The land-based jet guy may have to have a runway in excess of 60,000 ft. long, with his heavy load of fuel, and the carrier guy will need 120 ft. and 3*g* off the catapult; but once in the air he can have a fast and smooth ride to 40,000 ft. and a smooth ride above to 50,000 ft. or more.

"At these altitudes he has some things to reassure him and a few to remember with caution. In the first place it is nearly always smooth and quiet up there and is rather conducive to thinking. Probably the most uncomfortable feature is the tug of the oxygen mask when he turns his head to read some gage that the mock-up board has hidden way back under his left elbow. Although his speed may be near the critical Mach Number, the dynamic pressures are low and the indicated air speeds are low; it is not possible that he can incur excessive structural loads no matter what he does. In a straight-wing fighter at 40,000 ft., he has an operating speed range from the stall at about 120 knots indicated to the speed for limiting Mach Number, which may be about 240 knots indicated. But if he wishes to maintain level flight, or to climb, he must keep the air speed around 170 knots or above. In the upper middle part of this range he may pull accelerations up to 2.5*g* in order to accomplish maneuvers that involve curved flight paths. This means that turns can be executed and banked smoothly up to about 70° in approximately level flight. Any attempt to pull higher accelerations will produce buffet and drag rise, accompanied by loss of speed and altitude. Toward the high and low ends of the speed range, the available accelerations fall off, and he is limited to shallower turns. If he increases speed by

gliding at full power, he will soon approach the limiting Mach Number, and the usual compressibility troubles will make their appearance. The characteristic drag rise will be noticeable; in order to force the plane well into this disturbed speed range, he will have to drop the nose still further to increase the steepness of the glide. As speed does increase, he will notice, in the most typical case, first, a high-frequency vibration of the air frame and then a mild longitudinal trim change, nose down, followed by irregular lateral oscillations. Finally, there will be a nose-up change in trim with sharp increase in elevator forces, a point that marks the limiting speed for satisfactory control. Above this point it may be necessary to maneuver with the elevator tab control, or the stabilizer adjustment, because of the excessively high forces. This condition is actually one of stability and automatic recovery, though in tests we are always on the lookout for the rather disturbing condition where the shift may be in the reverse direction, as it was in the old P-38 with such disastrous results. Here we are most grateful for modern research and design methods.

"At these altitudes all such phenomena are mild, and in no case have they given us serious trouble. However, if it becomes necessary to descend rapidly, for either tactical or emergency reasons, or to execute a gunnery attack against a target below, it simply cannot be done without brakes. With them the pilot feels reassured and comparatively free to maneuver. From 40,000 ft. in the Banshee or Panther, with dive brakes extended, he can roll over on his back and pull straight down into a long dive without getting into trouble.

"A pilot, at 50,000 ft., is in a bad fix if he loses the engine and cabin pressure, unless he can immediately open his brakes and make a fast dive to an altitude where he can exist on unpressurized oxygen. This has frequently been necessary following flame-outs during early tests before correct engine fuel regulation had been obtained.

"For some reason, not clear to me, lateral control has a tendency to become coarse and 'touchy' at high altitudes. It is difficult to center the ailerons, and more or less continuous lateral oscillations are induced by the pilot in attempting it. Pilots frequently describe it as 'lateral instability,' a feeling that they are balancing themselves on a pin point—unable to smooth out the control. It is probably due to a combination of circumstances, such as poor centering characteristics, aggravated by the effect of low temperature on the system friction inboard of the boost and therefore multiplied by the boost ratio. At the same time, there is an increase in aileron effectiveness, with reduced density, and a decrease in damping in roll. Where this 'wobbliness' is present, it does make the pilot uncomfortable.

"Operating at high altitudes, the pilot of a jet is seen to be comfortable after all refinements have been made and all bugs eliminated. He must be thoroughly familiar with the limits of his aircraft, and in maneuvering he must use precise judgment and some forethought. Many disturbing and confused reports have come from pilots who did not have a clear understanding of the problem. He must, of course, be prepared for any of the possible emergencies. For example, we have had many flame-outs and a few engine failures from other causes which lost him cabin pressure; there have been a few cases of canopies coming open inadvertently and of oxygen failure, these latter, of course, being serious matters.

"As the operating altitude is lowered, the situation changes considerably, and the pilot has to think rather differently about things. First of all, he may develop high dynamic pressures, indicated air speeds, and load factors which can produce structural damage. If he runs up into the critical Mach Number range, the characteristic irregularities become more severe and possibly dangerous if carried far enough. But he has much wider limits within which he may maneuver; he becomes concerned with wing loads due to acceleration and rolling. He is less likely to approach critical Mach Numbers, but he still has important use for the dive brakes, particularly if he wishes to descend rapidly. At the higher indicated air speeds, 350 to 450 knots indicated, opening the dive brakes produces much the same sensation as full application of brakes in an automobile at 50 m.p.h. At low indicated air speeds they are hardly noticeable.

"As he descends to low altitudes, he is likely to run into frosting of the canopy and windshield, inside, sometimes to a critical extent. This requires flight by instruments—if the instrument faces are not also fogged up—and a delay in the approach procedure. For the present, we must expect some fogging, hoping it will be confined to areas where it will not impair his approach vision. He may also run into atmospheric turbulence, which can be most uncomfortable at high speeds but need not be serious unless associated with applied accelerations. We have observed a few high-speed structural failures in which turbulence was undoubtedly a contributing factor.

"He may also run into birds and this is extremely serious. We have had three collisions in 3 years—none fatal, but all disturbing. Apparently, you can almost count on a bird getting out of the way below 200 knots, but you can't at 400 and 500 knots. It is not necessary to be going extremely fast for a bird to become lethal to an airplane. In each of the above collision cases, the little feathered things tore up all the metal in their way. One took the vertical tail clean off the Banshee at 500 knots indicated air speed.

"One of the most impressive things about jets, to a pilot on his first hop, is the difficulty of slowing them down to the approach to a speed where the landing gear can be lowered. It is, of course, the result of low overall drag and residual idling thrust. But the fact remains that a jet can be flown just as slowly as any other plane with equivalent wing loading, in spite of widespread impressions to the contrary. It's not economical, but in many cases it's necessary, and it's always desirable during approach. The so-called 'tactical approach,'

(*Continued on page 33*)

Aircraft Propulsion

A Report on the Fifth Annual Flight Propulsion Meeting, Cleveland, March 24

By

S. Doree Black,* A. L. Pomeroy,† and Uwe H. von Glahn‡

(I) Review of Morning Session**

BEFORE A CAPACITY AUDIENCE of over 500 leading scientists and engineers specializing in all phases of flight propulsion, the I.A.S. Fifth Annual Flight Propulsion Meeting opened on March 24 in Cleveland.

This year's sessions covered three important phases of propulsion: The general morning session pointed up current and future important phases; the afternoon session dealt with the problems of "Turbine-Powered Transport Aircraft"; and the evening session covered "Ice Protection for Gas-Turbine-Powered Aircraft."

The meeting was opened by S. Paul Johnston, Director, I.A.S., who, after a few remarks, introduced the chairman of the morning session, A. T. Colwell.

Mr. Colwell, Vice-President, Thompson Products, Inc., and the chairman of the I.A.S. Cleveland-Akron Section, then introduced the first speaker of the session. The paper entitled "Do We Need Turboprops?" was prepared by E. V. Farrar, Executive Engineer, and R. E. Johnson, Field Engineer, Wright Aeronautical Corporation, and was delivered by Mr. Farrar.

Mr. Farrar stated that in order to answer the question "Do we need turboprops?" we must examine all the different types of power plants under development and prepare to fit them into the future aircraft speed-range spectrum.

"In view of the present state of development of the various types of engines,...we have confined this analysis to the air-cooled radial reciprocating engine, the turboprop, and the turbojet. The factors of airplane range, airplane speed, and cost of operation with these engine types are examined as applicable to commercial transport airplanes."

After making certain assumptions pertaining to a reasonable means of analysis of power plants, keeping the comparison of engines as simple as possible, energy utilization curves were shown for the three types of engines discussed. These curves are a plot of per cent energy vs. air speed, where total fuel energy is taken as 100 per cent. From this 100 per cent energy line is subtracted the various losses, showing, finally, the remaining useful propulsive energy as percentage of total fuel energy vs. true air speed. This type of analysis was conducted for several types of engines: (1) geared supercharged reciprocating engine; (2) compound reciprocating engine; (3) reciprocating engine with maximum compounding utilizing all possible exhaust energy for feedback to the propeller drive or for supercharging, with an intercooler between the supercharger and engine cylinders; (4) turbojets with low-, medium-, and high-compression ratios, each at optimum fuel-air ratio; and (5) turboprops at low-, medium-, and high-compression ratios, each at maximum fuel-air ratio.

The results of these analyses are given in Fig. 1 and show that the turboprop engine is the most economical from a fuel energy standpoint between approximately 250 and 625 m.p.h. (For Fig. 1, see page 22.)

Having considered the optimum fuel utilization of the several engine types, these types were then investigated in terms of the cost for each to transport 1 ton of load 1 mile.

After outlining five essential items of cost of power plant, it was shown by Mr. Farrar that certain difficulties occur in establishing relationships for analysis. For the purpose of this study, various assumptions had to be made after examination of existing data, and these were discussed in detail. The cost variables were applied to five different engine types in appropriate airplanes by using the A.T.A. cost formula. The results are given in Fig. 6 of the authors' paper, which shows optimum speed range for each type of power plant.

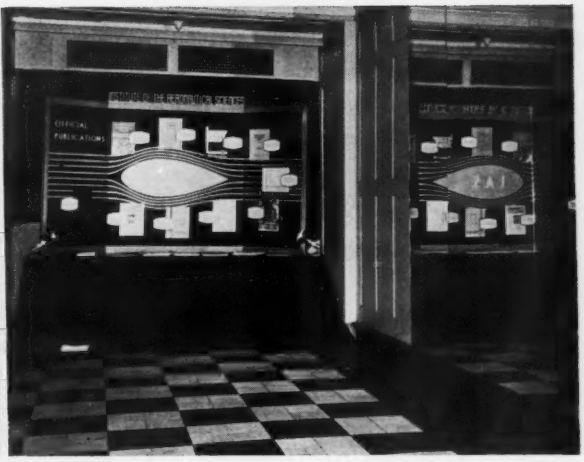
* Associate Professor of Aeronautical Engineering, Case Institute of Technology.

† Staff Engineer, Thompson Products, Inc.

‡ Lewis Flight Propulsion Laboratory, N.A.C.A.

** By Dr. S. Doree Black.

"Have you registered?"—*(Left to right)* Janette Sullivan, Irene Kives, Rosemary Weiss, and Mary Lou Gosney, of N.A.C.A.'s Cleveland Laboratory staff, pop the question and make this necessary formality a much more pleasant task.



The Institute's new, staff-built, and -designed publications display makes its debut at the Cleveland meeting. The primary function of the display is to familiarize members and nonmembers alike with everything published by the I.A.S.

Before drawing any conclusions from this analysis, the authors outline a number of practical operating and design problems that must be resolved and summarize their findings. They conclude:

"(A) If we had turboprops today we would use them. Operational problems would be solved.

"(B) From the commercial air transport point of view we believe we need turboprops. However, we are unwilling to hazard a guess as to whether or not the commercial advantage warrants the rather large cost of development in the next few years.

"(C) We feel that the turboprop will reach full development after the turbojet, unless military requirements make it advisable for the Services to support turboprop development more fully than seems probable at this time."

A comment from the floor on the comparison of this problem with that of 20 years ago, involving air-cooled vs. liquid-cooled engines, brought out the fact that this problem is not one of reliability, a most prevalent question of the times in regard to liquid vs. air cooling.

H. H. Ellerbrock, Jr., Chief, Turbine Cooling Research Branch, N.A.C.A., inquired as to the assumed turbine inlet temperatures. Mr. Farrar stated that these were assumed as lying between 1,500° and 1,700°F. and were not varied beyond this during the analysis.

T. G. Dunkin, Engineer, A. V. Roe Canada Ltd., remarked that, for estimation of price per engine per pound, a great deal depends upon the installation and that, for estimating, their figures were about $13 to $15 per horsepower and a similar amount per pound weight. However, $5.00 per pound of thrust with a lower amount for turbojet than for reciprocating engines also seemed a reasonable figure. He also inquired as to high speed and the icing problems in estimating usefulness of the turboprop engine. Mr. Farrar agreed with the cost estimating figures. He remarked that high speed generally means high cost and that this would be discussed in later papers. They had felt that icing was not a major consideration, it having been especially minor for centrifugal compressors and not so important as generally thought in the case of axial types.

Mr. Colwell commented on the excellence of the paper and introduced the next speaker, Thomas B. Rhines, Chief Development Engineer, Hamilton Standard Division, United Aircraft Corporation, who discussed "Design Refinements in Modern Propellers."

Mr. Rhines remarked that design refinement is a continuous process, the results of which can only be shown by comparison of the state at one time with that prevalent several years before. As an illustrative example he cited: "In 1938, the DC-3 transport was equipped, for its 1,200-hp. engines, with propellers 11.5 ft. in diameter and weighing 397 lbs. each. In 1947, the DC-6 airplane appeared in service with 13-ft. propellers weighing 395 lbs. to absorb the 2,400 hp. of each engine. At substantially the same weight, the later propellers handle double the power, provide reverse braking operation, are equipped for synchronization, operate with a maximum pitch change rate over three times as great, and, in addition, perform aerodynamically at a higher efficiency. Yet the propellers of both airplanes answer the same general description: aluminum-alloy blades, hydraulic operation, and standard hydromatic hub structure. The differences represent design refinements.

"From time to time, the emphasis in the refinement process appears to change from one aspect to another—from structure, to function, to aerodynamics.... Today, however, aerodynamic performance is the center of attention."

Before discussing current activities in this field, Mr. Rhines showed the efficiency variation of an ideal propeller—that is, one of dragless airfoils—showing that this propeller would not have 100 per cent efficiency

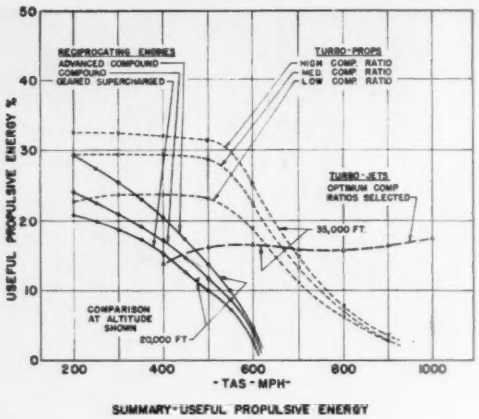


Fig. 1.

unless it were infinitely large. The ideal performance is the goal strived for by designers. The effect of varying different parameters was presented. It was shown that "the detailed aerodynamic design of a propeller blade for optimum performance must be carefully related to the flight conditions for which high efficiency is required. The process of refinement works against the losses that reduce efficiency or that cause reductions in aircraft or engine performance. . . . The endless path of refinement has led to extensive use of propeller strip analysis for study of the problems, with related analysis of the propeller blade as a complex structure.

"Propeller strip analysis will account for most of the variables in design and operation. Experience has shown that the theory is reliable, within satisfactory limits, for relatively conventional propellers. Typical theory application neglects some factors such as interaction between sections and boundary-layer action in centrifugal fields. Nevertheless, it has become an important tool for improvement of propeller-blade design by evaluating the complex effects of section loading, pitch distribution changes, airfoil camber modifications, and airfoil thickness."

Diagrams were presented showing the airfoil characteristics used in strip analysis, the losses from high drag, and the penalties of too high a value of v/ND. For high-speed propellers, airfoil sections must be as thin as structural requirements and weight considerations will allow. Propeller sections operating above the speed of sound over most of the blade length are required in modern application. Here, propeller performance depends primarily on supersonic section drag. Propeller theory, however, is imperfect. "Its demonstrated adequacy for routine refinement steps does not prove that it will properly handle the problems met in further advancing propeller performance. Practical test results are required and are daily becoming available."

The United Aircraft wind tunnel is capable of testing 4-ft. models at free-stream Mach Number up to 0.92. Typical test results for several two-bladed propellers were shown, indicating that the flight Mach Number at which large losses begin to occur has been moved upward by 0.1 in the past 7 years.

Three distinct operating régimes are noted for propeller design. The first is for low flight speeds, where peak performance is achieved by operating at a particular v/ND; the second is at a forward Mach Number of about 0.5, where tip section speeds approach critical values. At a Mach Number of almost 0.8, the losses from excessive v/ND begin to exceed those directly chargeable to section speed, and the third régime begins.

Mr. Rhines stated: "The condition at high speed is such as to allow a marked decrease in propeller size as compared with conditions in the moderate speed régime. For peak performance, the diameter can be about two-thirds as large, but a practical figure is more nearly three-fourths, since most cases will have resorted to some overloading at the lower speed.

"It should be noted that the 'supersonic' propeller need not be a fundamentally different article from a conventional unit. It needs (however) refinement to reduce section drags.

"A prediction of the extent to which performance can be improved by drag reduction for supersonic operation depends largely on the degree to which airfoil thickness can be reduced. . . . Altogether, it is probable that efficiencies better than 75 per cent, and perhaps 80 per cent, can be achieved at Mach Number 0.9, . . . provided that near optimum operating conditions and diameters are used."

In conclusion, Mr. Rhines discussed structural problems, remarking that design must strive for inherently stiff blades to reduce the proximity of resonance without too much use of thickness as an easy source of stiffness. A final illustration showed some of the radical, as well as conventional, wind-tunnel model blades tested during development of design refinements.

George W. Brady, Chief Engineer, Propeller Division, Curtiss-Wright Corporation, commented on the efficiencies at high Mach Number, pointing out that at forward Mach Number 0.9 the local Mach Numbers at all sections of the blade were well above 1.0. Higher efficiencies had been achieved than indicated by Mr. Rhines, being well in the 0.60 to 0.70 range for forward Mach Numbers greater than 1.0.

John L. Crigler, Langley Aeronautical Laboratory, N.A.C.A., remarked that, by using sections having L/D of near 10, propeller efficiencies of almost 80 per cent had been reached at $M = 0.9$.

Mr. Rhines added that, using section characteristics obtained from experiments on rotating propellers, strip theory enables calculation of propeller efficiencies in excellent agreement with experiment, although both torque and thrust calculated values are underestimated.

Mr. Colwell remarked that it is now well to note some developments and problems of power plants that may well be the prime power source for flights of the future. He then introduced Dr. Allen E. Puckett, Head, Missile Aerodynamics Section, Hughes Aircraft Company, who presented a paper prepared under coauthorship with Richard H. Edwards, also of Hughes Aircraft

Company, entitled "The Optimum Performance of Short-Range Rocket-Powered Missiles."

Dr. Puckett stated that: "The range of a rocket-propelled missile is determined by the ratio of propellant weight to gross weight, by drag and atmospheric characteristics, and by details of the way in which the propellant is used—i.e., the rate at which burned. . . . For an extremely long-range missile, it is presumably the distance at which the missile strikes the earth; in this problem, both the acceleration of gravity and production of lift are essential factors. For a shorter range missile, whose flight is essentially at constant altitude, the definition of range becomes more arbitrary. It may be the distance at which the missile velocity drops below some minimum value, selected on the basis of desired characteristics at flight termination, or it may be the distance over which its average speed can be maintained above some minimum value. In the short-range missile problem, a much simplified investigation of the performance may be made by ignoring the effects of lift and gravity. . . .

"The interesting questions concerning the performance of the short-range missile may be asked in several ways. If, for a given missile in a given atmosphere, the propellant weight and burning rate are specified, the entire subsequent history of the missile's flight is obviously determined. If a particular range is arbitrarily selected, the average missile velocity over that range and the terminal velocity may be calculated. We may then investigate how these average and terminal velocities depend on the burning rate and, in particular, whether there exists an optimum burning program that will maximize either of these velocities. This problem is, of course, equivalent to finding the minimum propellant weight necessary to achieve a particular average speed or terminal speed over a fixed range. It is also equivalent to finding the maximum range that may be reached with given propellant and with specified average or terminal speed.

"In the first and simplest version of this problem, the burning rate may be taken as constant, so that burning time is the only parameter. In its more general form, arbitrary variations of burning rate are considered, and variational methods are used to select an optimum."

The flight of the short-range missile was considered in two parts: the power-on period and the coasting or power-off flight. The equations of motion for these two conditions were demonstrated and developed.

The equation of motion during horizontal power-on flight was shown to become the general nonlinear type, which can be integrated only numerically

$$\overline{m}\,\frac{dv}{d\theta} + C_D\,v^2 + \frac{d\overline{m}}{d\theta} = 0$$

where C_D equals drag coefficient at zero lift.

The equation of motion during power-off flight is

$$(dv/d\theta) + C_D\,v^2 = 0$$

Speakers at the morning session, under the capable chairmanship of Arch T. Colwell, Vice-President, Thompson Products, Inc. *(left)* are: E. V. Farrar, Executive Engineer, Wright Aeronautical Corporation; Thomas B. Rhines, Chief Development Engineer, Hamilton Standard Division, United Aircraft Corporation; Allen E. Puckett, Head, Missile Aerodynamics Section, Hughes Aircraft Company; and A. Kalitinsky, Chief Engineer, NEPA Division, Fairchild Engine and Airplane Corporation.

As a first approximation, the drag coefficient is assumed to be a constant, representing some mean value. Using this and other simplifying devices, Dr. Puckett showed what might be obtained through solutions of these equations. For instance, he showed that the terminal velocity always increases with increase in burning distance (or burning time). For maximum terminal velocity at a given range, the burning time should therefore be extended over the entire flight time.

Increase in β (dimensionless burning time parameter) contributes directly to increased flight time, but the accompanying increase in η_1 (power-on flight distance) decreases the time spent in coasting flight. It was demonstrated that, for certain values of range and average flight speed, an optimum burning rate for minimum flight time does exist; for other values, the best burning time may be either zero or the entire flight time, depending on how the rate is programmed.

Constant and variable burning rates were then discussed, Dr. Puckett reaching the following conclusions: "The attainment of optimum performance of a short-range missile is essentially a matter of balancing momentum loss due to drag during the burning period against the loss during the coasting flight and of making the sum a minimum. If terminal velocity and range only are fixed, then, with either constant burning rate or optimum burning program, the missile should be driven as slowly as possible over the range and then accelerated to the desired velocity by a thrust pulse at the end of the flight. This is a rather absurd and impractical extreme but indicates, at least, that another specification must be given in order to define a practical desired performance.

"If average flight speed is fixed, the best performance is obtained at short ranges with zero burning time and at longer ranges with some finite burning time. The

Exhibitors at the Cleveland

(Top left): Thompson Products, Inc.
(Center left): The Cleveland Pneumatic Tool Company
(Center right): American Steel & Wire Company
(Bottom left): Lear, Inc., Romec Division
(Bottom right): The B. F. Goodrich Company

Meeting

Carter Hotel

March 24, 1950

(Top right): Pesco Products Division, Borg-Warner Corporation
(Center left): Aluminum Company of America
(Center right): Lewis Flight Propulsion Laboratory, N.A.C.A.
(Bottom left): The Parker Appliance Company
(Bottom right): Jack & Heintz Precision Industries, Inc.

best possible performance would be obtained with a two-step motor, producing a single pulse at the start to a definite velocity and then a smaller constant thrust sufficient to hold the velocity exactly constant for a certain time. At long ranges, the decrease in required propellant becomes appreciable.... At these long ranges, it is also clear that the neglect of gravity is probably important, and the induced drag of a lifting system for a constant altitude flight should also be included."

For various reasons, "it is expected that the calculations should give no more than an indication of trends and of the possible existence of optimum programs that must be discovered by more accurate calculations in particular applications."

Mr. Colwell's requests for comments resulted in remarks from representatives of the Air Force, universities, industry, and the N.A.C.A.

Colonel Marvin C. Demler, U.S.A.F., Wright-Patterson Air Force Base, remarked that he was pleased to have heard such a paper in view of the steady development and increased importance of rocket-powered missiles.

Roy E. Marquardt, President, Marquardt Aircraft Company, jokingly remarked, upon inquiry for comment by Mr. Colwell: "We still prefer to use a ramjet."

Both Daniel Waldo, Jr., Guided Missiles Division, Fairchild Engine and Airplane Corporation, and Robert H. Boden, Aeronautical Research Center, University of Michigan, said that the stage programming of rocket burning was an interesting development. Mr. Boden stated that this was especially important in the present development of Jato units.

Walter T. Olson, Lewis Flight Propulsion Laboratory, N.A.C.A., inquired as to which parameter seemed the most logical in studies of choice of fuel for the propellant: mass moved per unit of fuel weight flow, or thrust developed per unit of volume of flow. Dr. Puckett replied that fuel or propellant choice was a separate problem and that his studies were for a specific propellant. The influence of the burning time on the weight of the unit was not considered.

A. M. Rothrock, N.A.C.A. (Washington), stated that this type of study was excellent in aiding the programming of research, especially in the use of costly facilities. He said that, because of the large expenses involved, extreme care must be exercised in programming all research, especially of this nature.

Mr. Colwell then introduced Anthony Kalitinsky, Chief Engineer, NEPA Division, Fairchild Engine and Airplane Corporation, after remarking that because of the nature of this subject no question-and-answer period would ensue at the close of Mr. Kalitinsky's talk. The title of the paper was "Atomic Power and Aircraft Propulsion."

Mr. Kalitinsky stated: "The release of atomic energy has opened an extremely interesting new field of engineering application. It is also, potentially at least, an important and wide field. However, before the practical and useful applications of atomic energy as a source of power can be achieved, the engineering profession and the industry of this country must take an active part in its development.... The actual complexity of the applied atomic sciences, or 'Nucleonics,'... is about comparable to that of supersonic aerodynamics or to that of three-dimensional shell theory in stress analysis. This should not be taken to mean that the development of atomic power is a simple undertaking. On the contrary, it is an extremely complex one, which will require the utmost ingenuity in designing around some obstacles and in overcoming others."

After a brief introduction to Atomic Physics, Mr. Kalitinsky remarked: "The questions now arise: What are its (atomic energy) fields of usefulness, and in what fields can it most profitably be applied? In attempting to answer these questions, the basic characteristics of atomic fuel must be examined. It is a fuel with an extraordinary high concentration of energy in a small mass, but it is also a scarce and expensive fuel. It is expensive both in procurement and in operation. It is logical, then, to look to applications that have a high premium on performance rather than on direct cost per kilowatt-hour. It is also logical to look to applications where unique results can be achieved by using the high concentration of energy rather than to applications that would merely be duplicating results obtainable from other fuels. The application to aircraft propulsion meets these requirements very well indeed.... A fuel with a heating value of 40,000,000,000 B.t.u. per lb. can obviously be expected to give practically unlimited range....

"Several basic types of power plants can be adapted to utilize atomic energy for the propulsion of aircraft. They are all thermal power plants, since fission energy is released predominantly in the form of heat. Some thought has been given to the direct production of electricity from the fission process, but there is, at present, no known practical way of achieving this."

A steam turbine, turbojet, ram-jet and rocket type were diagrammed and discussed.

Mr. Kalitinsky concluded with a summary of some of the major engineering problems that lie in the path of practical realization of atomic aircraft power plants. "As far as the atomic-powered airplane itself is concerned, it must be designed for very high speeds to take advantage of the special characteristics of atomic power and make its application worth while. It will certainly be a large airplane. It will be unusual in that it has to be designed for a landing weight that is equal to the take-off weight, since practically no fuel is used up in flight. Since radiation intensity decreases inversely with the square of the distance, the crew locations should preferably be selected as far away from the power plant as possible, permitting a certain amount of weight-saving in the shield. Finally, the structural requirements will be somewhat different from those of conventional airplanes, since the 'fuel' load will be concentrated in one spot, in the reactor, rather than widely distributed. In this last respect, however, they might

not differ too widely from some of the thin-winged, high-speed airplanes now under development which do not use wing tanks."

Mr. Colwell called the morning session to a close at noon after reminding the members and guests that a half-hour period before the luncheon was available to them for viewing the interesting technical exhibits and displays (see pages 24 and 25) of local propulsion and aircraft parts manufacturers.

(II) Review of Afternoon Session*

THE AFTERNOON SESSION, under the capable direction of Chairman Edward Warner, of the International Civil Aviation Organization, featured four papers that shed much light on the future trends in commercial air transport designs. All of the papers were based on comprehensive studies of the potential advantages of gas-turbine-powered aircraft. Both the turboprop and the turbojet were carefully analyzed.

Although speed is of paramount importance in air travel, it is becoming more and more essential that it be obtained at a price that is attractive to the customer. Both the turboprop and the turbojet speeds are above those obtained with current reciprocating engines. However, each has an optimum speed and range, and it becomes necessary to study carefully which is better suited for the wide requirements imposed by commercial air travel. That this has been the subject of much study was clearly evident by the engineering data presented in this session.

The papers took into consideration important factors such as economics, passenger comfort, all-weather flying with schedule reliability, and conversion of present-day equipment. It was emphasized that future aircraft must be designed to fit available ground facilities, since air lines cannot continue to buy runway length and approach zone rights indefinitely and remain solvent.

A significant characteristic of all four papers was the apparent superiority of the turboprop to meet these wide requirements. For speeds of 300 to 500 m.p.h. with relatively long range, the turboprop appears to be the answer. These data are based entirely on existing design propellers. The development of supersonic propellers would undoubtedly further enhance the advantages of the turboprop combinations.

Charles Froesch, Chief Engineer, Eastern Air Lines, Inc., presented the first paper entitled "Looking Ahead with Air Transport." This paper discussed the basic requirements of future commercial aircraft and suggested designs that could best meet these demands. The author pointed out that while speed is attractive, it must be justifiable, economical, safe, and comfortable. (For the complete paper by Mr. Froesch, see page 34 of this issue.)

In a paper entitled "Propulsion Analysis for Long-Range Transport Airplanes," by Alexander Kartveli, Vice-President and Chief Engineer, Republic Aviation Corporation, the comparative performance of the compound reciprocating engine, the turboprop, and the jet are determined in a currently available large transport. This airplane, the Republic Rainbow, powered with four turbosupercharged reciprocating engines, has undergone many wind-tunnel and flight tests, thus providing a datum line for evaluating gas-turbine power plants. The airplane was designed with the view of accommodating gas-turbine engines, with their higher powers and greater speeds, with minor changes.

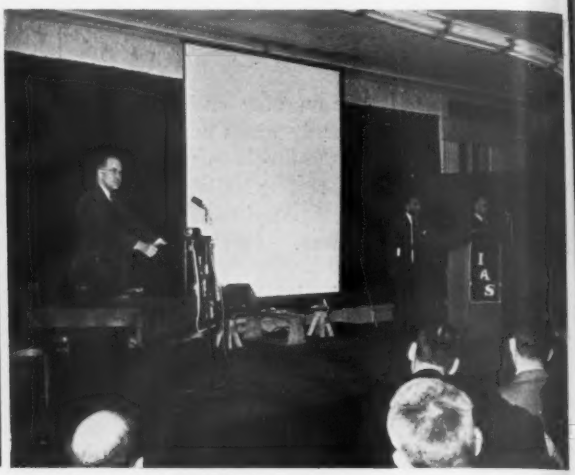
Dr. Edward Warner (*center*), President of the Council, ICAO, acts as Chairman for the afternoon session. Speakers are (*left to right*): R. D. Kelly, Superintendent of Technical Development, and F. F. Davis, Engineering and Maintenance Assistant to Vice-President—Operations, United Air Lines, Inc.; Charles Froesch, Chief Engineer, Eastern Air Lines, Inc.; Dr. Warner; A. Kartveli, Vice-President—Chief Engineer, Republic Aviation Corporation; and W. C. Keller, Project Engineer, Consolidated Vultee Aircraft Corporation.

For this study, the airplane was basically unchanged, although certain small adjustments were made in the thickness and area of the wing to bring the aerodynamic qualities of the wing in accordance with the speed obtainable with a given power plant. In this comparison, the pay load, as well as the fuselage and its contents, was left the same in all cases.

In this analysis, curves of range versus cruising speed at altitudes of 20,000, 30,000, and 40,000 ft. were computed. These data showed the following comparison. At 20,000 ft. the reciprocating engine has a slightly greater range than the turboprop at speeds of 300 to 350 m.p.h. At 365 m.p.h. the range for both engines is equal, but beyond this speed the range of the reciprocating engine decreases rapidly and stays below that of the turboprop. The curve for the turbojet engine shows a range considerably below the two others over the entire cruising speed range. However, the maximum obtainable speed for the jet is some 70 m.p.h. greater than the turboprop.

At 30,000 ft., the turboprop shows a substantial improvement in range over the reciprocating engine for a given cruising speed. For a fixed range such as 3,000 miles, the cruising speed of the turboprop is 50 m.p.h. greater than the reciprocating engine. Here,

* By A. L. Pomeroy.



The meeting this year was outstanding for its discussions from the floor, as indicated by the above pictures of Christopher Clarkson, British Attaché for Air *(left)* querying Mr. Kartveli and Mr. Froesch *(right)* during the Turbine-Powered Transport Aircraft Session.

the maximum speed for the turbojet is again 70 m.p.h. faster than the turboprop but for a much shorter range.

At a cruising altitude of 40,000 ft., the turboprop definitely has assumed the highest position at all speeds within the capability of the engine. The reciprocating engine and the turboprop attain their maximum range at the same speed—namely, 410 m.p.h. However, the range of the turboprop is some 20 per cent greater. The curve for the turbojet has improved and gives practically a constant range (around 2,000 miles) for speeds of from 420 to 570 m.p.h.

Mr. Kartveli draws the following engineering conclusions from this comprehensive analysis. As greater speeds are called for, coupled with long range, it appears that the reciprocating engine is no longer practical, since its range drops rapidly after 400 m.p.h. The turboprop at altitudes of 30,000 to 40,000 ft. offers any range between 2,500 and 4,500 miles at speeds of 550 to 580 m.p.h. For nonstop transoceanic and transcontinental flights, the turboprop appears to be the answer. For short runs of 2,000 miles or below, the pure jet gives substantially higher speed.

The air lines' point of view was reflected in a paper entitled "Turbine Powered Transport Development," by R. D. Kelly and F. F. Davis, of United Air Lines, Inc., which was presented by Mr. Kelly. The authors state that, as a result of first-hand experience in British gas-turbine-powered aircraft, it was their opinion that such transports are certainly attractive. Of striking importance are the facts that cabin noise is reduced substantially and that there is almost complete absence of engine vibration—the most important improvements as far as passenger comfort is concerned.

The authors of this paper introduce an important factor that must be considered in the evaluation of power plants for air transports—namely, the variable winds encountered enroute. Data were shown which illustrated that wind effects frequently necessitate flying at varying cruising powers and at varying altitudes if schedules are to be met. The jet engine, because of its relatively narrow operating altitude range (for optimum efficiency), may look less favorable under such conditions. The authors showed data that indicated that turboprop aircraft can give better schedule reliability in the face of adverse winds than either the pure jet or the piston engines.

This paper emphasized the importance of using block-to-block time rather than tower-to-tower time. The problem of stacking during instrument weather is, of course, a serious one when considering the jet with its high rate of fuel consumption. It appears that the turboprop can more readily be integrated into our present traffic pattern. In summation, the authors state: "...that the turbine power plant provides remarkable advances in passenger comfort. We believe it is the proper avenue by which further speed advances can be achieved economically. It is still problematical as to whether the turbojet or turboprop will prove best in day-in and day-out operations. Perhaps each will have its own field of supremacy.

"The turboprop seems the logical next step, since its operating characteristics are not far different from those of present craft. Turboprop-powered aircraft should easily operate into and out of present airports and can more easily be integrated into present traffic patterns. They should have good flexibility of operation.

"The ultimate safety of turbine-powered aircraft should be better than that of those using piston engines and gasoline. However, the initial safety record will likely not be so good, and the matter of safety precautions should not be taken lightly by the designers and builders."

That a gas-turbine-powered commercial airplane will be an actuality, was brought forth in a paper by W. C. Keller, Project Engineer, Consolidated Vultee Aircraft Corporation, entitled "Propeller Turbines in Transport Aircraft." This describes the project to install an Allison 501-A2 engine in the Convair 240. This power plant is essentially one-half of the military T-40 engine, which is a dual turbine unit. The 501 is rated statically

at 2,550 shaft hp. and 415-lb. thrust, with an equivalent shaft power at take-off speed of 2,750 hp. Dry weight of the engine is 1,225 lbs. for a weight-per-horsepower figure of 0.448.

The installation of the Allison engine in the Convair 240 will give a weight-saving of approximately 1,400 lbs. with higher take-off powers and better power fall-off characteristics with altitude. Allowances were made in the basic design of the 240 for higher power ratings so that the basic structure will be unaffected. Calculated flight performance data show that the 240 will be materially improved with the turboprop engine. The first airplane will have a gross weight of 41,200 lbs., will cruise at 310 m.p.h. at 16,000 ft. (75 per cent rated power), and will have a top speed of 350 m.p.h. Service ceiling is to be 32,500 ft., and take-off distance over a 50-ft. obstacle is 2,100 ft.

The author estimates that with production volume, the costs of the 501 will be competitive with reciprocating type engines of the same output. It is expected that flight tests of this airplane will begin this summer. In concluding, Mr. Keller stated: "American turbine development, allowed to progress, is yielding successful and satisfactory power plants for both military and civil aviation. The Convair 240 is but one modern air frame capable of gaining higher operational returns through propeller-turbine power. The recent press releases indicate that at least three other major air-frame manufacturers have concrete plans in their programs for propeller turbines. Other engine manufacturers have propeller turbines either on the test stand or in the design stage which will figure in future designs. The propeller-turbine-powered transport will become a permanent category of aircraft for short-range operations and will demand a high degree of competition to be displaced in long-range operation by jet propulsion."

The discussion that followed the papers brought out some interesting points. As we fly at higher speeds, serious consideration must be given to provide some means of preventing structural damage caused by impact from birds. Leading edges of both the wings and the tail surfaces may have to be reinforced. The question was raised as to whether gas-turbine engines can be used for commercial application in view of the fact that they contain much strategic material. Engine builders replied that substitution programs are currently under way and are hopeful that the use of critical materials can be avoided. In answer to several questions, it was apparent that faster progress will be made in reducing the specific fuel consumption of the turboprop as compared to the turbojet. This is because of the fact that the turboprop does not depend on a jet for propulsion, and, therefore, pressure ratios can be increased without substantially reducing propulsive efficiency.

Air-line operators stressed the importance of increasing the overhaul life of gas-turbine engines before they can be used for commercial service. Little is known regarding the actual engine life in civilian air transport.

Considerable concern was expressed over the discomfort and possible injury caused by rough air while at high speeds. The British reported that flights with a Comet had indicated that this perhaps was not so serious as originally anticipated. In flights between 30,000 and 40,000 ft., rough air was encountered and accelerations from $-1g$ to $+2g$ were recorded. These were rapid and of short duration, and it was stated that the passengers might have had trouble if their seat belts were not fastened. It was the opinion of the British that the rough-air problem for high-speed flight must be studied, but preliminary indications are that the problem is not insurmountable. One means that was discussed was the possibility of air-borne radar so as to avoid flying in rough-air areas.

This session most definitely indicated that the industry is embarking upon a new era for commercial air transports. While the development of gas-turbine-powered transports for civilian use has lagged in this country, it now appears to be gaining impetus. Because of certain inherent advantages and ease of transition, it seems that the first flying turbine aircraft will be propelled with turboprops. This will provide much experience and will permit the solution of many problems that can perhaps pave the way for turbojet transports for commercial use.

(III) Review of Evening Session*

THE EVENING SESSION under the chairmanship of Willson H. Hunter, Lewis Flight Propulsion Laboratory, N.A.C.A., was devoted to a discussion of the icing problems associated with high-speed, high-altitude turbojet-powered transport aircraft. The program consisted of three papers prepared by members of the staff of the Lewis Flight Propulsion Laboratory combining theory and experimental data on the meteorological and operating problems involved in the icing protection of jet-powered aircraft. The first paper discussed the phenomenon of supercooled droplets and the meteorological conditions that could be expected on a typical flight path for a high-speed, high-altitude transport airplane. In the second paper, the factors affecting the external heat requirements for the air-frame and engine components requiring icing protection were discussed. The final paper discussed the characteristics of heating systems that can be used to obtain the heat required for icing protection from the several energy sources available on a jet engine and independent heat sources and estimated the airplane performance losses associated with heat or power extraction from these sources.

The first talk, presented by Paul T. Hacker and coauthored by Robert G. Dorsch, both of the Flow Physics Section, Lewis Flight Propulsion Laboratory, was entitled "Meteorology and Physics of Icing." The speaker described the spontaneous freezing of supercooled water droplets and summarized recent data on

* By Uwe H. von Glahn.

N.A.C.A. experts provide their usual informative papers at the evening session through the following speakers and coauthors *(left to right)*: Willson H. Hunter, Chairman, Member, N.A.C.A. Subcommittee on Icing Problems, Lewis Flight Propulsion Laboratory; Paul T. Hacker and Robert G. Dorsch; Thomas F. Gelder and James P. Lewis; and Harrison C. Chandler, Jr., and Stanley L. Koutz.

the liquid-water content and droplet sizes associated with stratus- and cumulus-type clouds.

The mechanism of ice formation by supercooled droplets impinging on the surfaces of aircraft has long been of interest to those in the field of icing research. Supercooled droplets in clouds are deposited on aircraft surfaces by droplet deviation from the air stream lines by inertia separation. The droplets, if supercooled, are believed to freeze upon impact and adhere to the surfaces. Fundamental studies of the spontaneous freezing of supercooled droplets indicate that the freezing temperature is a function of droplet size. An interesting film showing the progressive spontaneous freezing of various size droplets was presented by the speaker. Also shown were pictures of the change in droplet cross-sectional shape as freezing progressed through the droplet. Mr. Hacker indicated that droplets of a given size did not always freeze at the same temperature but froze over a range of temperatures with a pronounced frequency peak at a particular temperature. A decrease in droplet size is accompanied by a lower mean spontaneous freezing temperature. For a high-speed turbojet transport, the importance of supercooled droplet impingement is more significant than for conventional airplanes, because at high speeds the inertia-separation effect becomes greater and causes an increase in the impingement area on the surfaces.

The speaker then enumerated the meteorological information necessary to design an icing protection system. The factors to be considered are: (1) liquid-water content in the air; (2) mean effective droplet size and, if possible, droplet-size distribution; (3) ambient-air pressure and temperature; and (4) horizontal and vertical extent of icing conditions. From over 500 encounters with ice in instrumented aircraft, considerable information has been gathered in the low to medium altitudes of the conditions conducive to icing. Two types of cloud are fairly representative of most icing conditions: cumulus types for large vertical development and stratus types for large horizontal extent. Calculations and data show that the water content decreases in cumulus clouds above 15,000 ft. Similarly, the higher the stratus clouds are encountered, the lower the water content. An extreme value of water content for cumulus clouds appears to be about 1.6 Gm. per cu.m. at 15,000 ft. For stratus clouds, an extreme value of 0.6 Gm. per cu.m. occurs near sea level and decreases rapidly with altitude, reaching a value of 0.08 Gm. per cu.m. at 21,000 ft. Average values of water content are approximately one-half the extreme values for both cloud types. Average values of the mean-effective droplet size are found to be about the same for both types of cloud, being in the order of 15 to 20 microns in diameter, with extreme values of about 50 microns at altitudes ranging from 7,000 to 12,000 ft. Data on both droplet size and water content are, unfortunately, nonexistent for altitudes greater than 24,000 ft. Consequently, values of droplet size and water content at the high altitudes are estimated in the subsequent papers.

Mr. Hacker then pointed out that the vertical extent of icing conditions in cumulus clouds varied from 6,000 to 9,000 ft., whereas icing conditions in stratus clouds were generally in the order of 3,000 to 5,000 ft. in thickness. These values, however, are based on limited observations. The horizontal extent of individual cumulus clouds rarely exceeds 10 miles, although a cluster of such clouds would constitute a severe icing problem. Stratus clouds, on the other hand, may extend several hundred miles.

A summary of the icing conditions to be considered as design values by the following speakers in an analysis of the heat requirements necessary for ice prevention on a turbojet transport aircraft was given as shown in Table 1. These design values are generally slightly above measured average values but are considerably below the maximum values.

The second paper, entitled "Determination of Heat Requirements for Turbojet Aircraft," was presented by Thomas F. Gelder, coauthored with James P. Lewis, both of the Icing Research Branch, Lewis Flight Propulsion Laboratory.

The external heat requirements for a hypothetical turbojet transport airplane operating according to a typical flight plan were analyzed, particularly with respect to the effect of high-speed and extended altitude operation of such an aircraft. The aircraft is assumed to have a gross weight of 125,000 lbs. with a wing span of 125 ft. Four turbojet engines are used to power the aircraft. The meteorological conditions conducive to icing are selected in accordance with known data at the lower altitudes and are extrapolated to the higher alti-

TABLE 1

Velocity (M.p.h.)	Altitude (Ft.)	Temperature (°F.)	Drop Size (Microns)	Liquid-Water Content (Gm./Cu.M.)
350	0–10,000	20	15	0.6
350	10,000–20,000	0	20	0.4
350	20,000–30,000	−15	15	0.2
500	30,000	−30	15	0.1

tudes where such factors as the range of liquid-water content, droplet size, and extent of icing conditions have not been established. The flight plan assumed by Mr. Gelder consisted of take-off and climb at 350 m.p.h. to an altitude of 30,000 ft., a cruise condition at 500 m.p.h. thereafter, and let-down similar to the ascent. For a range of altitudes, air temperatures, droplet size, and liquid-water content based on the previous paper, the heat requirements for ice protection of the aircraft were examined. Of particular interest is the determination of the minimum speed at which the adiabatic temperature rise over the surfaces is sufficient to prevent icing. The minimum velocities required to attain a 32°F. surface temperature in a cloud are shown in Fig. 1 over an altitude range for various ambient-air temperatures. The solid diagonal line shows the minimum flight speeds that the jet transport must achieve to maintain a 32°F. surface temperature at the assumed pressure altitudes and air temperatures of the flight plan. At the high altitudes and low air temperatures, the surface temperature is less than 32°F. for speeds below 600 m.p.h. Consequently, icing can be expected on the jet transport throughout the climb and let-down conditions below 20°F. and in the cruise condition at 500 m.p.h. in icing clouds below 5°F. The effect of a saturated atmosphere on the adiabatic surface temperature is also indicated in this figure by a comparison of the adiabatic surface temperature in dry air at an ambient air temperature of 20°F. and a similar curve in saturated air.

Mr. Gelder next discussed the factors affecting ice formations on the wing and empennage surfaces, including such topics as droplet impingement on the exposed surfaces, convective heat transfer rates, evaporation of water, and extent of surfaces to be heated. Analysis of water impingement on the wing surfaces indicates that the maximum amount of water catch—8 lbs. per hour per ft. of span resulting from the combined effects of speed, droplet size, and angle of attack of the wing—occurs at the medium altitudes.

Wing thermal icing protection can be obtained in three ways: (1) All the impinging water can be evaporated; (2) the water can be maintained in a liquid state over the entire wetted surface; and (3) ice can be allowed to form and then be removed periodically. In the first case, if all the water can be evaporated within the impinged area, the heated surface area and heat requirements would be at a minimum; however, the surface temperatures and the local rate of power or heat input would probably be excessive. It is therefore necessary to provide a heated area aft of the impingement area over which the excess water or runback may be evaporated. The heated area required is a function of the water catch and rate of evaporation of the water—hence, surface temperature. In the case of complete evaporation within the impinged area, the water catch is of greater significance than the surface temperature; the reverse is true if evaporation is allowed to occur for some distance aft of the impinged area.

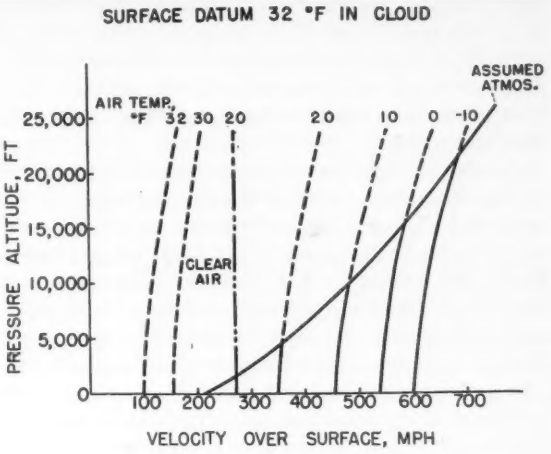


FIG. 1.

A general discussion of the effects of air temperature, altitude, and air speed on the convective heat-transfer coefficient followed. It was shown that the convective heat-transfer coefficient decreases with altitude and increases with an increase in air-speed. Ambient air temperature has little effect on the coefficient. With respect to heat-transfer calculation for the turbojet transport, experimental data have indicated that convective heat-transfer coefficients are calculated for a turbulent boundary layer. Calculation of Hardy's evaporation factor indicates that the altitude effect exceeds that of air velocity and air temperature effects, the latter two factors being of comparable magnitude. Calculations in the region of water runback are based on partial wettedness of the surface. Experimental investigations show that reasonably accurate results may be achieved if the evaporation factor is multiplied by the percentage of the area wetted.

The minimum heat required to evaporate all of the impinging water is shown in Fig. 2 as a function of the area over which heat is applied. The heat requirement increases with an increase in heated area and a decrease in the surface temperatures. For the aircraft under consideration, 11,500 B.t.u. per hour per ft. of span

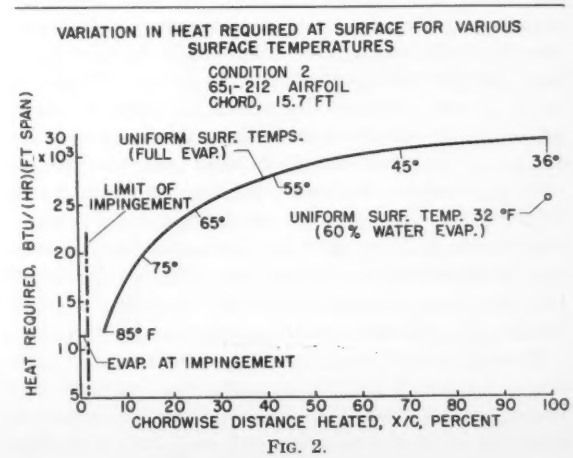


FIG. 2.

are required if the water is evaporated in the impinged area; whereas, 25,400 B.t.u. per hour per ft. of span is required if the entire wing surface is heated to 32°F. and only 60 per cent of the water is evaporated. Similar results can be expected during let-down at this altitude and speed.

Another thermal means of attaining icing protection is the method of electrical cyclical deicing. In this method, ice is permitted to form on a surface, and heat applied periodically results in shedding of the ice formations. No rational analysis for cyclical deicing is available at present, and the heat requirement is therefore estimated from preliminary studies conducted at the Lewis Flight Propulsion Laboratory. Present knowledge indicates that a heat-off period of about four times the length of the heat-on period will provide satisfactory operation. Calculations indicate that the greatest power input occurs during the climb condition at 25,000 ft. and is in the order of 14.5 watts per sq.in. This value is approximately 25 per cent of the heat input necessary to evaporate the water in the impinged area.

Protection requirements for other airfoil-shaped components, such as the tail surfaces, follow the same general trends shown for the wings. Windshield protection is less than 1 per cent of the airplane heating requirements and is in the order of 2,100 B.t.u. per hour per sq.ft. for a V-type configuration.

Two thermal means of icing protection for the engine components are considered. The first method consists of injecting hot gases into the airstream at the nacelle inlet, thereby raising the air, water, and wall temperatures above freezing. The quantity of hot gas necessary for icing protection can be computed by the ordinary mixing temperature equations. The percentage of engine mass flow that must be bled back from a heat source is independent of altitude, although in terms of B.t.u. per hour it is a direct function of the mass flow. The greatest effect on the hot gas required is the air temperature with liquid-water content which has only a second-order effect. The maximum amount of hot gas is required at the climb condition at 25,000 ft. The second method is by direct surface heating of all engine components by either hot-gas or electrical means. In the absence of a compressor screen (presumably retracted in icing conditions), the inlet guide vanes impose the greatest icing hazard and require a large amount of heat. In general, the calculation of heating requirements is made along similar lines as for wings, except that all the surfaces must be heated, although only a minimum surface temperature of 32°F. is required. Again, the highest heat requirements occur at 25,000 ft. in the climb condition. Power savings in the order of 70 per cent can be achieved, if the vanes are electrically heated, by using cyclical deicing rather than continuous heating.

Heating requirements for the remaining engine components such as inlet screen (if not retractable), island fairings, bearing struts, accessory housing, and cowl lips are found to vary with icing and operating conditions in approximately the same way as the guide vanes.

A summation of the heating requirements for all the aircraft components requiring icing protection indicates that the climb condition of 15,000 ft. is the most severe condition if the wings are heated to evaporate the water at impingement and requires 2,840,000 B.t.u. per hour. Of particular significance is the relatively small heat requirement for protection of the engine, approximately 3 per cent of the total heat required. Because the wings probably cannot be heated to evaporate the water at impingement, a heating requirement between 2,840,000 and 6,120,000 B.t.u. per hour (the latter value occurring if all surfaces are heated to 32°F.) will be necessary. The final value will depend on the percentage of surface heated. By the use of cyclical deicing of the wing, tail, and guide vane surfaces, the total heat requirements are reduced to 720,000 B.t.u. per hour at the climb condition of 25,000 ft.

The final paper of the evening session, entitled "Thermal Anti-Icing Systems for High-Speed Aircraft," was presented by Harrison C. Chandler, Jr., coauthored with Stanley L. Koutz, both of the Altitude Wind Tunnel Branch, Lewis Flight Propulsion Laboratory. The previous two speakers having presented the design icing conditions and the external heat transfer rates for the various aircraft components, Mr. Chandler proceeded to enumerate and evaluate the heating systems and various heat sources available to supply the required heat for complete icing protection of all critical components. The speaker began his discussion with a résumé of the configuration variables associated with a typical ice-prevention system for a wing. Analysis shows that hot gas circulated to the wing leading edge can best be distributed by means of channels having a large length with respect to the perimeter and a small depth normal to the heated surface. For all calculations of gas flow, a gas temperature of 350°F. is used. In the case where all of the water is evaporated in the impinged area, the total heat of the gases flowing into the wing is seven times more than the external heat loss calculated in the preceding paper. Substantial savings in heat input and, hence, in gas flow can be made by heating to 20 per cent of chord. If the heating is confined to 10 per cent of chord, a large weight-saving can be accomplished with only a moderate increase over the 20 per cent of chord heating requirements. The effect of gas-flow channel size is indicated by a 25 per cent increase in gas-flow requirements for a $^{3}/_{16}$-in. depth compared to a $^{1}/_{8}$-in. depth. A reduction in gas temperature from 350° to 250°F. necessitates an increase of 60 per cent in the gas flow to obtain similar icing protection.

The utilization of electrical power for cyclical deicing of the wing shows that in terms of B.t.u. per hour, the electrical system requires only from 25 to 40 per cent as much heat input. Similar results are obtained for the tail surfaces that require about 50 per cent as much heat as the wings.

(*Continued on page 44*)

A Test Pilot Looks at the Jets (Continued from page 19)

with a big zoom to kill speed, is hardly more than evidence of poor judgment 10 to 20 miles back.

"The major defect in the flight characteristics of our high-powered single-engined propeller-driven fighters and attack planes is a large variation in directional trim with speed. This change is inherent, and no satisfactory method has yet been devised for its correction other than dual rotation propellers. It is due to the varying twist in the slipstream acting on the vertical tail and to lateral shifts in the center of thrust with changes in angle of attack. It is extremely annoying to the pilot, producing high rudder forces and requiring frequent readjustments of rudder trim. Jets are free of this defect, a fact that adds much to the pressure of flying and maneuvering them. They may, and usually do, have better directional stability than propeller aircraft. At normal speeds the rudder becomes superfluous, and pilots find that they may fly smoothly through all normal maneuvers with feet flat on the floor.

"Unrelated to this, however, is another problem that has plagued jets. High speed design has produced a persistent tendency toward directional oscillations, either poorly damped or undamped. Whatever the various causes may be, they have frequently been aggravated by surging or 'sloshing' of the large fuel load. At high speeds the frequency is high, and the pilot may not be able to damp them out with rudder control because of the inability to establish the correct phase relationship in his toe movements. He may aggravate them in the attempt. The appearance of these oscillations is inconsistent and annoying, but they are going to become more persistent in future designs, and artificial damping may be necessary—another 'Rube Goldberg' invention to aid in preventing life from getting any simpler.

"As more and more jets become operational, the major piloting problem is flight planning, and the execution of the flight plan, to remain within the endurance limits in the face of the inevitable weather troubles. Our present jet fighters have a range equal to, or better than, the piston-engine fighters, provided they are operated at high altitude. But they have nothing like the endurance under any circumstances. It is possible to slow down a piston engine to the minimum power required for flight and so reduce the fuel consumption that surprising increases can be made in endurance in an emergency. It is not possible to do this in jets; even at minimum power the jet engine is a fuel hog at low altitudes. Enroute navigation must be more accurate and must be performed in half the time. Yet, at high cruising speeds, the present low-frequency range stations are not adequate, especially when there is static, as there always is in summer. Direct map reading and visual orientation from high altitudes are useful only under ideal conditions. To add to the general uncertainty, the V.H.F. radio becomes a continuous din of transmissions received from extreme ranges from all directions.

"Flight plans and changes thereto will frequently give the pilot all the mental exercise he can handle both before and during flight—always because of the critical endurance factor. For instance, should he cruise at 40,000 ft.—where his fuel economy is best—and accept a headwind of 100 knots, or should he drop down to 28,000 ft. where it's only 30 knots? This sort of a problem is to be solved on compact and confusing small slide rules that various people are devising. But it takes a great deal of test data to arrange the slide rule in the first place, and then some considerable understanding by the pilot.

"The approach to destination must be more precise, because there is probably little margin of time for reorientation or correction of any mistake in navigation. No other phase of jet piloting will demand so much skill, judgment, and experience as bad weather and instrument approaches at destination with the time element critical. I do not believe that any pilot can become properly qualified to handle this sort of situation except through doing it, at comparative leisure, in conventional airplanes.

"Instrument flying in jets is further complicated by the effect of speed on gyro instruments. All their deficiencies and inadequacies, including those that are inherent, are magnified in proportion to the square of the velocity. The horizontal accelerations, which are comparatively high and long-sustained at high speeds, have an aggravated effect on the erecting systems of gyro horizons; turn errors are greatly increased. The old turn-and-bank indicator is reasonably good up to 200 knots. It registers only that part of the turning rate which lies in the plane of the wings. The pilot wants to know his turning rate in the plane of the horizon. But at high speeds, even at low rates of turn, his wings are banked up, far from the horizontal plane, and the indicator reveals little to him. Pilots must understand these deficiencies in order to cope with them; we suspect that they have already been contributing factors to some misadventures that were not clearly explained. Fortunately, the high-speed parts of the flight will be less critical to instrument troubles in general, and, where precise instrument flight is essential, the plane must be slowed.

"When this jet guy finally breaks out into the clear and sights the carrier or the field, and during his approach thereto, he is happy about the vision. It's far superior to any that could be obtained in single-engined propeller aircraft—provided, of course, his canopy, windshield, and instruments are not all frosted over and provided he's not just out of fuel at this point. Throughout the flight he has enjoyed having his ejection seat; he hasn't even been up long enough to get tired of just sitting in it. But, since two people have actually used it successfully in emergencies, he is really pleased with it (except Lieutenant Holbrook, who tried very hard the other day but it wouldn't go off; you can imagine his humiliation at having to climb out in the old fashioned way)."

Looking Ahead with Air Transport

CHARLES FROESCH*
Eastern Air Lines, Inc.

Introduction

THE AIR TRANSPORT industry is now at the end of its first postwar development phase during which the airlines expanded their transport fleets and services and readjusted their economic thinking to integrate, collectively, our industry in the national transportation pattern.

It must now develop a sound merchandising policy and aggressively plan to consolidate its gains and firmly progress by looking ahead equipmentwise, operationwise, and trafficwise in order to implant in the mind of the traveling public that air travel is a necessity for the conduct of business and an incontestable advantage for pleasure, without any mental evasion on his part.

In looking ahead and before we can set down the operating requirements of the newer jet-powered transport aircraft, we must first find the answers to the following questions:

(1) What speed can we justify economically and at what speed can we best serve the public interest?

(2) How large can we afford to design and build these new aircraft to meet frequency of schedule requirements and yet earn a profit to be reinvested in new equipment at a later date?

(3) How can we best use these new jet propulsion developments, which offer greater speeds than heretofore thought practically possible?

It is with trepidation that I offer my own thoughts on these questions, realizing full well that crystal-ball assumptions had to be taken and that an engineer should not explore any territory where angels fear to tread.

Nevertheless, limited experience in the field of jet transport design permits one to take liberties, not wholly unwarranted, in an effort to construct a picture that may be practically realized a decade hence.

How Fast?

It is a human trait to want to travel fast as long as it can be done safely and comfortably. It is a fact that the economic development of any land and its people is closely related to the speed of its transportation means.

This fact can be recognized in our country by the development of the automobile, the railroad, the steamship, and, of course, the airplane, which has consistently increased its speed by leaps and bounds since the Wright brothers made their first flight at Kitty Hawk.

Yet there must be a speed beyond which the law of diminishing returns becomes manifest, and little would be gained except by going much faster, perhaps in the order of Mach 3 and beyond.

Domestically speaking, it would seem that a comfortable, overnight, eastward flight from coast to coast should be our goal for the present. For instance, one could leave Los Angeles at 11:00 p.m. Pacific Time and arrive in New York at 7:00 a.m. Eastern Standard Time. This means a 5-hour flight, averaging 500 m.p.h. block to block and cruising at 550–600 m.p.h. Going west, one could leave New York at 9:00 p.m. Eastern Standard Time, and arrive at Los Angeles at 11:00 p.m. Pacific Time—that is, 2 hours later.

Likewise, the same speed would permit $^1/_2$-hour flight from New York to Chicago and $2^1/_2$ hours return, representing a little more than the normal commuting time now experienced in our large cities.

Such speed would also permit a leisurely $^1/_2$-hour flight from New York to Washington, which is a heavily traveled route; a 2- to $2^1/_4$-hour flight from New York City to Miami, Fla.; or $2^1/_2$-hour flight from New York City to Houston, Tex. This should be economically feasible and still remain within the transonic speed range.

It is not believed that we will soon fly at supersonic speeds domestically, because they are not necessary commercially or practical from a cost standpoint. We know that it takes a different airplane to fly efficiently once the sonic barrier has been penetrated, and the complications required to design an aircraft to fly at subsonic *and* supersonic speeds may not be warranted for some time to come.

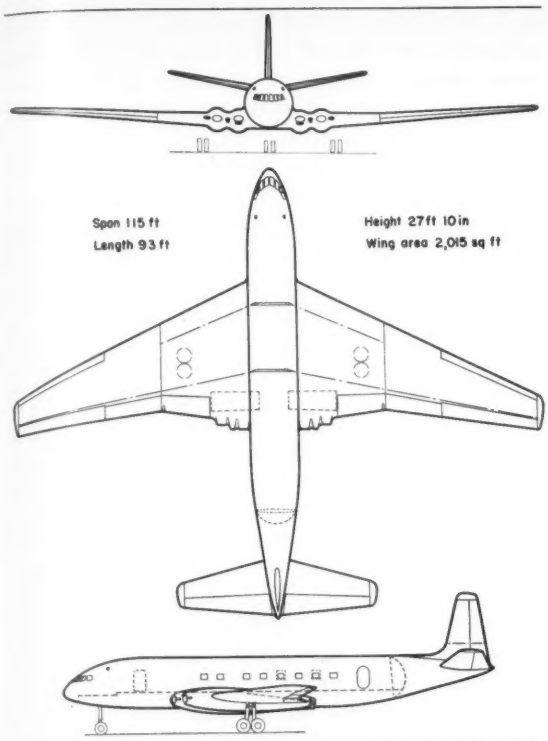
However, we should not totally dismiss from our mind the need for higher speed in transoceanic operation, which involves greater distances and the possibility of aerodynamic discoveries that may open the

Courtesy De Havilland Aircraft Ltd.

FIG. 1. De Havilland Comet in flight.

Presented at the Fifth Annual Flight Propulsion Meeting, I.A.S., Cleveland, March 24, 1950.

* Chief Engineer.



Courtesy De Havilland Aircraft Ltd.

FIG. 2. De Havilland Comet—three-view.

Courtesy A. V. Roe Canada, Ltd.

FIG. 3. A. V. Roe Jetliner in flight.

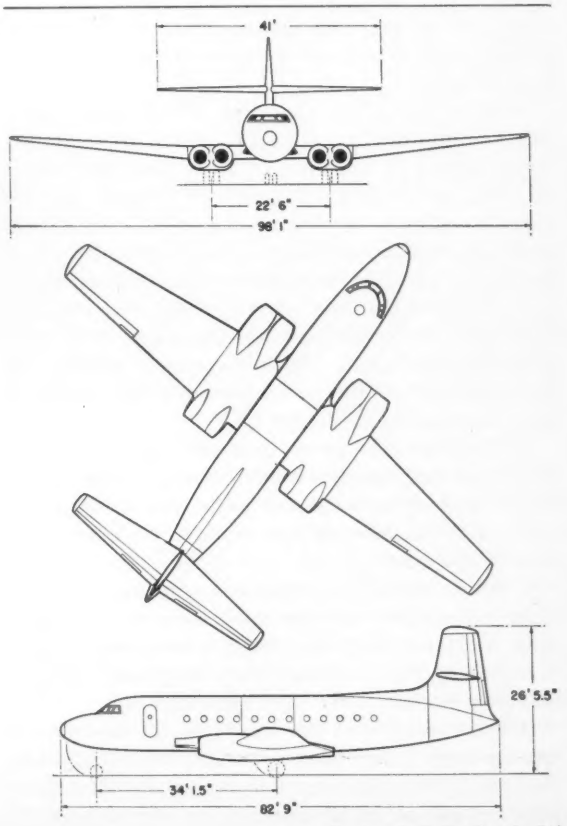
commercial practicality of supersonic speeds. It is not inconceivable to envisage twice the speed suitable for domestic operation in overseas service. This would permit crossing the Atlantic Ocean overnight or flying from New York to Buenos Aires in 12 hours.

The application of jet propulsion to transport aircraft can make the continental schedules I have discussed possible in the near future, as evidenced by recent developments. For instance, the British de Havilland Comet (Fig. 1) is an excellent example of what can be done. Seating 36 passengers plus crew, it cruises close to 500 m.p.h. and has a range of approximately 2,000 miles with a 12,000-lb. pay load which is remarkable considering the high fuel consumption of gas-turbine engines today (Fig. 2).

Similarly, the Canadian A. V. Roe C102 Jetliner (Fig. 3), with a normal seating capacity of 40 passengers and a cruising speed of over 450 m.p.h., has an approximate range of 1,100 miles with 11,000-lb. pay load (Fig. 4).

The conception of these two aircraft, designed to obtain the utmost from available turbojet engines, represents a decidedly forward step in aeronautical engineering. Future jet propulsion power-plant improvements will serve to enhance their worth and widen their application.

The greatest disadvantage of the turbojet engine today is its tremendous fuel consumption, which requires a high ratio of aircraft take-off weight for it and a place to stow the fuel needed for satisfactory range and adds to these the cost of such fuel. However, it is not inconceivable that a substantial reduction in specific fuel consumption of turbojet engines from 1 to 1.2 lbs. per lb. of thrust to 0.65 or 0.7 lb. per lb. of thrust can be made in the light of our present knowledge, thus doubling the practical range of a jet-powered aircraft or increasing its pay load correspondingly. This should be possible by increasing pressure ratios, combustion efficiency, and nozzle temperature and by utilizing better component design, turbine blade cooling, an annular combustion chamber, and a variable nozzle



Courtesy A. V. Roe Canada, Ltd.

FIG. 4. A. V. Roe Jetliner—three-view.

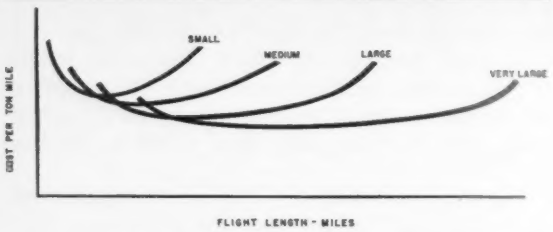


FIG. 5. Operating costs versus flight lengths.

area. A better knowledge of air inlet ram recovery and tailpipe configuration should also help the overall efficiency of jet propulsion power plants.

Diligently continuing our research and development work, it would seem possible to design gas-turbine engines to have their specific fuel consumption with a frontal area of not more than 1 sq.ft. per 1,000 lbs. of thrust for take-off. Specific weight could remain at 0.3 to 0.4 lb. per lb. of thrust. Lower weights are feasible, but I would prefer a heavier engine with built-in reliability and long life, since pay load is only worth while when we sell it and relatively few flights carry 100 per cent pay load.

How Large?

There is apparently no limit to the size of air-frame structure the designer can conceive or the shop can build, and the size of transport aircraft must, therefore, depend on the type of operation and the traffic potential to be handled.

Perhaps we can take a leaf from the operating experience of the motorbus industry. Some 25 years ago, buses varying in size from 15- to 20-passenger jitneys up to 60- and 70-passenger coaches were used—some at a profit, many at a loss. For over 20 years, every motorbus with the exception of specialized applications, has been of a 35–40-passenger capacity. We are, today, and I speak of domestic operation only, operating aircraft from 14- to 80-passenger capacity. It is axiomatic that the results of this operating experience will eventually dictate the most economical size or sizes to meet the needs of air traffic.

It is felt that perhaps two sizes will most satisfactorily handle all our passenger traffic—one of 36- to 40-passenger capacity for local and feeder schedules, and the other of 60- to 80-passenger capacity for limited and express operation.

When it comes to transoceanic schedules, substantially larger sizes must be used, because, fundamentally, size and range are closely associated. This is indicated by Fig. 5, which shows the general relationship between size, range, and operating costs.

It would seem that this would be the field for extremely large flying boats. To be economically efficient for a 3,000-mile range or more, any aircraft must be large. Thus, as we increase the size of transport aircraft, the flying boat becomes more attractive because of its higher useful load to gross weight ratio and because it can have a higher wing loading because of the unlimited size of takeoff and landing areas when compared with a landplane, which must depend upon airports limited in size due to cost and location.

How High?

A compromise must be reached on flight altitude. Jet power plants require that they be flown at high altitudes so that the reduced air-frame drag can partially offset their high fuel consumption. On the other hand, the optimum height at which transport aircraft must fly depends primarily on the mileage between stops.

Generally, below 500 miles, 20,000 ft. appears to be the limit with piston engines. For greater distances, the optimum altitude of the aircraft should be selected, with a maximum height of 25,000 ft., until such time as there can be no explosive decompression now occasionally caused by cabin window failure.

With jet-powered aircraft, it would appear that these altitudes should be raised to 25,000 and 35,000 ft., respectively. However, before this becomes a practical reality, it is mandatory that the design of cabin windows and doors be such that their reliability will be equal to that of primary aircraft structures; since elderly people in a pressurized cabin could not stand sudden decompression at 35,000 to 40,000 ft. It is a well-known fact that above 30,000 ft. the hydrogen in the blood begins to boil and that 100 per cent oxygen is required for normal body functioning. We must, therefore, limit our flight altitude to 30,000 ft. until explosive decompression becomes a remote possibility.

There is also the problem of lack of humidity, which we have discovered at as low an altitude as 20,000 ft. and which becomes more critical as we go higher. This must receive the serious consideration of the aircraft designer in an effort to reduce crew fatigue and increase passenger comfort. Furthermore, with the substantial increase in rates of climb and descent permitted by the use of turbojets on aircraft, the reliability of cabin pressurization equipment must be absolute, and, compared with present standards, it must be substantially improved before high-altitude flying becomes a daily routine.

Jet-Powered Aircraft

While it is not within the scope of this paper to outline specifications for jet-powered transport aircraft to be used in continental service, yet I want to list a few of the primary requirements that must be met to fulfill satisfactorily the needs of the types of air transportation I have previously discussed.

Generally, jet-powered aircraft, which will practically double our present transport aircraft speeds, will be sufficiently different from the type of transport aircraft used during the last 15 years to enable the aircraft designer to use his imagination without casting aside such service features found to be mandatory by past service experience. First of all, there must be no com-

promise with safety; second, they should contain the necessary provisions to operate under any weather conditions at any time; and, third, they must provide a greater degree of passenger comfort.

For *medium-range* operation, it is believed that the following characteristics should apply: (a) all-metal, low-wing land monoplane; (b) capacity for 60 to 80 passengers and 2,000 lbs. of mail and express (longitudinal seat spacing, 40 in.); (c) cruising speed, 600 m.p.h.; (d) range, 2,500 miles plus 2 hours fuel reserve at 15,000 ft.; (e) cruising altitude, 30,000 to 35,000 ft.; (f) stalling speed not to exceed 90 m.p.h. at landing weight; (g) powered with four turbojets so arranged that the noise cone at the tailpipe exhaust does not come within the cabin area; (h) pressurized to maintain a 5,000-ft. altitude in the cabin at a 30,000-ft. flight altitude; (i) cargo compartment located below cabin floor, readily loadable from the ground without special equipment; (j) accommodations for a crew of five, consisting of captain, pilot, flight engineer, and two cabin attendants; (k) tricycle gear with dual wheels for both nose and main gears; (l) structural design load factors to permit a 10 per cent increase in maximum licensable take-off and landing weights without subsequent structural modifications.

Among other desired specifications are: A preference for two-stage centrifugal compressor in the engines because of their low service and maintenance cost, although it is realized that axial-flow compressors may be necessary to achieve low specific fuel consumption; water injection for power boost to meet temperature accountability requirements; a runway length not to exceed 5,000 ft. at sea level; detachable wing tip fuel tanks to accommodate fuel required for longer range; submerged radio antennae; wings with moderate sweepback to provide some degree of gust alleviation; good load balance characteristic by permitting a high center-of-gravity travel; built-in steps in cabin entrance door; one-piece wing with relatively large removable tips; and the possibility of using boundary-layer control to improve lateral control at low speed and increase lift.

For *short-range* operation, the following characteristics appear to be the most suitable: (a) all-metal, high-wing land monoplane; (b) capacity for 36 to 40 passengers and 2,000 lbs. of mail and express (longitudinal seat spacing, 39 in.); (c) cruising speed, minimum of 400 m.p.h. at 20,000-ft. altitude. (d) range, 1,200 miles with 2 hours fuel reserve at 10,000 ft., and provision for added fuel tankage to obtain a maximum range of 1,600 to 1,800 miles with 2 hours fuel reserve; (e) operating altitude up to 20,000 ft., depending on mileage between stops; (f) stalling speed at landing weight not to exceed 75 m.p.h.; (g) powered with two turboprop engines; (h) cabin arrangement to consist of nine or ten rows of double seats followed by hand luggage rack directly opposite cabin entrance door (having integral steps), cargo compartment aft of passenger entrance door and accessible through an external door on same side of passenger entrance door, and cabin and cargo floor height not to exceed 40 in. from the ground; (i) cabin pressurized to maintain a 6,000-ft. altitude at a 20,000-ft. flight altitude; (j) tricycle gear with dual wheels for both nose and main gears; (k) structural load factors taken to permit a 10 per cent increase in take-off and landing weights during the service life of the aircraft.

Because much of the flight time will be spent at relatively lower altitudes, every effort should be made to reduce ride roughness in gusty air.

The aircraft should operate in and out of airports with 3,500- to 4,000-ft. runway lengths at sea level, and it should be of simple and rugged design with excellent maneuverability. The center-of-gravity range should be at least 30 in., and such range should be located as near the middle of the loadable area as possible to permit indiscriminate loading regardless of passenger-to-cargo load ratio.

This same type of aircraft, with large side loading doors and stripped of its cabin appointments, could readily be used as cargo aircraft. Both of these aircraft should permit an average flight utilization of at least 16 hours per day.

Airplane Versus Helicopter for Local Schedule Operation

There appears to be a growing recognition that, if we are to continue to furnish true local and feeder schedule service by air, the airplane may not be the most economical type of aircraft to use. With the advent of larger size helicopters and their increasingly reliable operation, they may eventually replace fixed-wing aircraft in our more densely populated areas because of their ability to land and take off closer to the traffic-generating centers.

No one questions the time advantage of air travel for distances of 200 to 500 miles or more, but a study of the *overall* speed for lesser distances reveals that it is sometimes slower than other means of surface travel and substantially higher in cost, particularly where the airports are located far from the cities they serve, either because of city size or terrain restrictions.

Time and cost infects all phases of air transportation. In business, it means greater efficiency, and, in pleasure, it means greater enjoyment. An analysis of overall air transport economics as they are today in local schedule operation readily shows that, while we emphasize speed, we sometimes demand from the passenger more of his time on the ground than we take in the air. Furthermore, with larger capacity aircraft, as presently designed, the cost of passenger handling according to established air-line procedure for personalized service has become excessive and cumbersome and irritating to both the passenger and the air-line personnel assigned to the task.

Fig. 6 shows the block-to-block speed of two twin-engined aircraft used in local service today and that of a modern helicopter. It will be seen that, purely on an

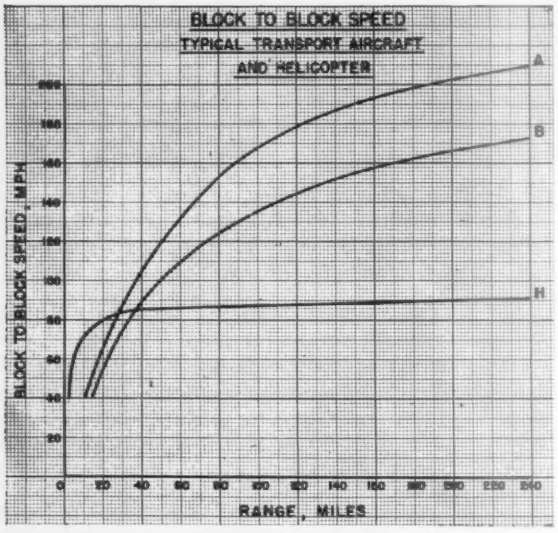


FIG. 6.

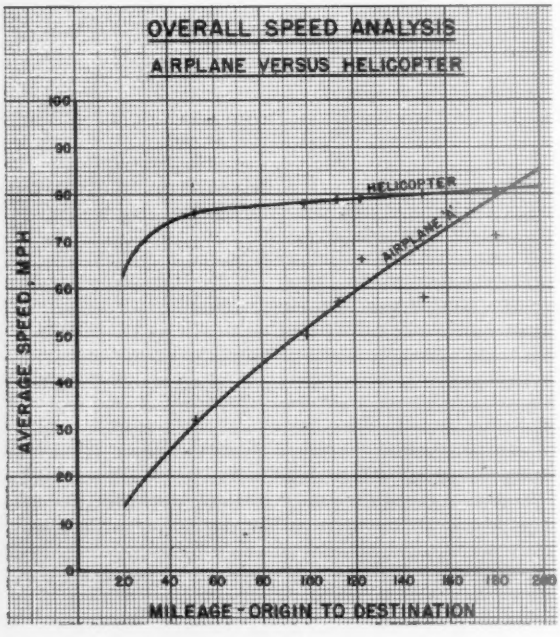


FIG. 7.

airport-to-airport basis, the helicopter is faster for distances of less than 30 miles. However, an overall speed analysis (Table I) of typical air-line flights between six sets of cities, using the best twin-engined performance today, shows an average overall speed between such cities of from 32 to 71 m.p.h. for distances varying from 51 to 181 miles. It is caused by the relatively low speed of ground transportation from the air-line terminal or city ticket office to and from the airport and by the time lost in transferring from ground transportation to air transportation.

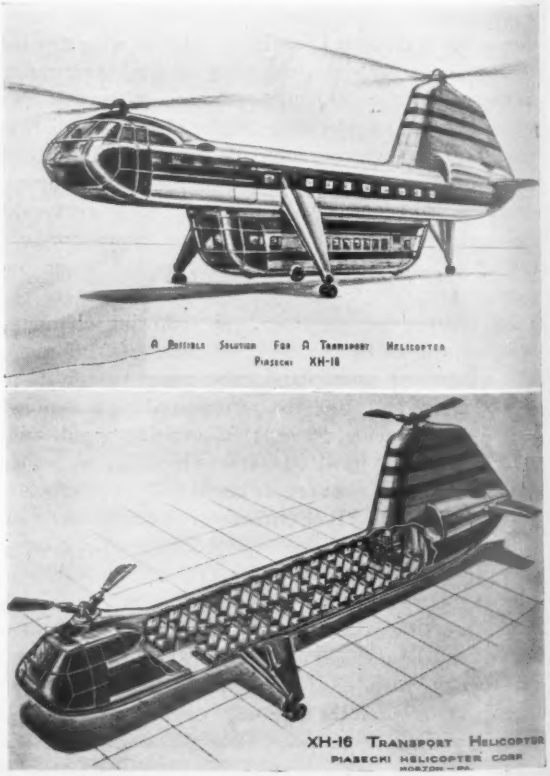
If a helicopter service could be provided from points in the city closer to the points of passenger origin and destination, its average overall speed would be equal to the block-to-block speed shown in Fig. 7, thus affording a substantial saving of time to the air traveler.

So much for speed. Now, if we analyze the overall cost of local schedule transportation, we find a similarly disparaging picture. Table II is an overall cost analysis of the same six sets of cities. It will be noted that the average cost per mile to the passenger is not less than 7 cents and as high as $9^1/_2$ cents per mile. It is true that in some cases rapid transit means could be used to lower this cost, but the traveler is often loaded with baggage which precludes the use of such means during peak travel hours.

The inescapable conclusion is that, while aircraft designers and air-line engineers are continually striving to improve the speed performance of transport aircraft, such improvements actually accentuate poorly located airports and ground-handling and ground-transportation deficiencies so that much of the gain is lost.

It should be possible, in the light of present knowledge, to design and manufacture a helicopter capable of carrying 25–30 passengers with their baggage, in addition to 2,000 lbs. of mail and cargo, at a cruising speed of 95–100 m.p.h. (Figs. 8a and 8b). Assuming the pay load to be 25 per cent of the gross weight, the total weight would be 30,000 to 32,000 lbs. and its cost, based on $15 per lb. would be around $350,000 in limited production.

It has been estimated that direct flight costs of such a helicopter, on the basis of 85 m.p.h. ramp-to-ramp speed, would be approximately $1.30 per mile with a



FIGS. 8a (*top*) and 8b (*bottom*). Transport helicopter.

TABLE I

OVERALL SPEED ANALYSIS

FLIGHT	AIR MILEAGE (AIRPORT TO AIRPORT, MILES)	FLIGHT SCHEDULE TIME *	BLOCK TO BLOCK SPEED, MPH	GROUND TRANSPORTATION MILEAGE * *	GROUND TIME * *	AVERAGE GROUND SPEED, MPH	TOTAL MILEAGE	AVERAGE OVERALL SPEED, MPH, AIRPLANE	HELICOPTER SPEED, MPH
BALTIMORE - WASHINGTON	40	22'	109 MPH	11	1H15'	8.8	51	32	76
CHICAGO - MILWAUKEE	82	35'	141 MPH	16.5	1H25'	11.7	98.5	50	78
NEW YORK - PHILADELPHIA	96	40'	144 MPH	17	1H10'	14.6	113	57	79
HARTFORD - NEW YORK	101	43'	151 MPH	22.5	1H10'	19.3	123.5	66	79
DETROIT - CLEVELAND	105	40'	158 MPH	45	1H55'	24	150	58	80
CHICAGO - INDIANAPOLIS	162	54'	180 MPH	18.75	1H40'	11.3	180.75	71	80.5

* BASED ON PERFORMANCE OF AIRCRAFT A FROM FIGURE 7

* * TAKEN FROM INFORMATION LISTED IN AIRLINE TIMETABLES

utilization of 2,500 hours per year, which is extremely conservative. This amounts to approximately $4^1/_2$ cents per seat-mile, assuming no mail or cargo revenue and 100 per cent load factor.

Insofar as landing facilities for helicopter operation are concerned, it would seem that an area 50,000 to 100,000 sq.ft.—or, roughly, 250 by 250 ft. or 300 by 300 ft.—would be sufficient, depending upon the proximity of other buildings and obstructions. Water frontage or spanning of docks would be suitable locations for heliports. The cost of such landing facilities would be but a fraction of that of our modern airports, and the construction of these facilities deserves serious consideration.

The use of helicopters for feeder operation is an interesting speculation because the important advantage of the helicopter is to pick up its traffic near its point of origin and deliver it near its real destination. Besides being faster for distances up to approximately 180 miles, the helicopter permits an increase in revenue mileage that is now given to ground transportation.

Air Cargo

While air cargo, which includes air express and air freight, is a relatively new kind of air traffic, it is becoming increasingly clear that, before we can make a sizeable dent in the tremendous freight market and operate profitably, we must have aircraft specially designed to carry cargo and we must have ground facilities to expedite the loading and unloading of air cargo in much less time and at lower costs than now prevail.

Today, cargo-carrying aircraft in commercial air operation are, primarily, converted passenger aircraft totally unsuited for cargo operation. Present operational difficulties are caused by high loading floors—a characteristic of all low-wing propeller-driven aircraft; improper fuselage cross section, which does not permit efficient space utilization; inadequate permissible unit cargo floor loading which often results in considerable structural damage and thus unduly keeping the aircraft out of service for repairs; and the lack of suitable cargo compartment air conditioning to meet the temperature requirements of various types of cargo.

These deficiencies have been the cause of many expensive refund claims from shippers and have resulted in the loss of their good will. They will continue to plague the industry until properly designed flight and ground equipment is made available.

There are several other basic problems to be solved. Packaging, for instance, has not received the attention it deserves. Another problem is tie-down equipment, which still leaves much to be desired.

All of these problems are closely related to the aircraft itself, and, while it is not within the scope of this paper to discuss cargo aircraft specifications, I want to leave with you a few guiding thoughts.

First of all, the aircraft cargo loading floor height from the ground should correspond to the average truck loading platform height so as either to permit cargo transfer directly from truck to aircraft or, if intermedi-

TABLE II

OVERALL COST ANALYSIS

FLIGHT	AIR FARE (INCLUDING TAX)	LIMOUSINE, BUS OR CAB FARE	TOTAL COST	TOTAL MILEAGE (FROM TABLE I)	OVERALL COST PER MILE TO PASSENGER
BALTIMORE - WASHINGTON	$2.88	$2.05	$4.93	51	$0.0966
CHICAGO - MILWAUKEE	$5.69	$2.00	$7.69	98.5	.077
NEW YORK - PHILADELPHIA	$6.73	$2.35	$9.08	113	.0805
HARTFORD - NEW YORK	$6.55	$2.25	$8.80	123.5	.0712
DETROIT - CLEVELAND	$7.48	$2.65	$10.13	150	.0675
CHICAGO - INDIANAPOLIS	$11.50	$2.40	$13.90	180.75	.0769

Courtesy Eastern Air Lines, Inc.

FIG. 9. Gladioli by air.

ate storage is needed for the collection of individual plane loads at the terminal, to eliminate the necessity of multilevel warehouse floors or the use of lifting equipment.

Second, the cargo compartment cross section should permit the maximum utilization of its volume, and the cargo floor should be level. Its understructure and covering should be able to withstand any type of cargo that may be offered to the carrier for transport. The cargo compartment height should be sufficient to permit loading of all floor area without the necessity of stooping. It should be well lighted and fully air conditioned. As a matter of illustration, here are typical cargo loads.

One typical cargo load is a 5-ton rudder stock, air-shipped thousands of miles to save time. Fig. 9 illustrates a partial load of gladioli. Flowers form a large portion of our air freight today and will probably continue to do so. Fig. 10 shows a mixed load of cargo which may include radios, toys, perfume, air parcel post, and other light and heavy articles of every type and description. Animals, such as race horses and dogs, are also flown in large numbers.

For operations averaging approximately 500 miles or more between stops, the cargo compartment should be pressurized to take advantage of the higher speed performance permitted, because direct flight costs vary almost proportionally to block speed.

Insofar as capacity is concerned, it would seem that for domestic operation a 20,000-lb. pay load with a net air-line range of 1,500 miles should be sufficient at a block speed of 300 m.p.h. or more if economically possible.

It is not believed that air cargo can successfully and economically be sold for short distances because of the higher ratio of ground-handling costs to flight costs. For instance, the ground-handling costs for a distance of 250 miles equal the total air-freight operational costs for that distance.

We must also assume that other ground carriers will streamline their operation to meet the competition air cargo is creating, thus limiting the value of air cargo only to its overall speed from point of origin to point of destination (it is a fundamental fact that speed costs money). Air cargo must thus supplement existing means by rendering a new service rather than compete with existing ones.

I do not want to leave the impression that the air lines will not fly local air cargo, since such cargo can be most efficiently flown on passenger aircraft used in local schedule operation to improve the overall load factor.

As air cargo gradually increases in volume and requires larger capacity equipment, the integral unit must be replaced with the detachable cargo carrier type similar to the well-established truck and trailer system. This will reduce the capital investment required for given ton/miles of cargo capacity and will reduce operating costs by permitting greater utilization of the air frame, which is the most expensive component.

NOTES ON DESIGN AND OPERATIONAL REQUIREMENTS

Today, we are thinking of jet-powered air liners to provide premium transportation requirements because they will introduce substantially higher speeds and will be more expensive to operate during their first few years in service. Eventually, we probably will find it desirable, if not necessary, to readjust our thinking and use them for all air transport services, because direct operating costs are inversely proportional to block speed.

As a matter of economic expediency, present equipment would be kept in high-density, low-fare service until the air lines can completely convert their fleets to jet power.

Fortunately, turboprops may be able to replace piston engines in the relatively near future, thus gaining additional economic benefits from present equipment types and giving the public higher speed and greater comfort.

The design of a jet-powered transport must be guided by two basic parameters: (1) The approach and landing speeds must be well within the ability of the flight

FIG. 10. Mixed air cargo load.

crew to handle. The reaction time must be such that it may be possible to make an error in judgment and correct it without introducing hazardous flight conditions. (2) It must be as fast as the art of aerodynamics will permit.

The tremendous increase in power permitted by jet propulsion, together with its low weight, demands the cleanest possible airplane to obtain maximum speed, because of the large fuel consumption of jet engines, if we are to obtain reasonable operating economy in terms of miles per gallon per pound of pay load. Therefore, it is obvious that maximum speed performance means the highest possible wing loading. This W/S will depend on improvements in auxiliary lifting devices to obtain the maximum coefficient of lift dictated for reasonable approach and landing conditions. We cannot continue to increase wing loading without a corresponding increase in lift coefficient to retain safe landing and approach speeds.

We apparently have reached the optimum in maximum C_L with flaps, as witnessed by the return of wing leading-edge slots in combination with flaps on some military aircraft. We look with suspicion on such an arrangement because of the possibility of failure of the slot to operate on one side, either because of icing or damage in flight by birds. This possibility would have catastrophic consequences.

Perhaps we should turn to the application of boundary-layer control, since, with jet aircraft, it would seem that the turbine compressor output could be diverted during approach and landing to substantially increase the lift coefficient without having to revert to the use of leading-edge slots. A great deal of research has been done on boundary-layer control but few results have found application in practice. It is hoped that further work will be done along this line.

The aerodynamic cleanliness of turbojet-powered transports, the lack of propeller drag, and the fact that at minimum r.p.m. jet engines deliver appreciable thrust pose a problem to the aircraft designer of first magnitude in the approach condition. Efficient air brakes, perhaps in the form of dive brakes, may be mandatory on all transport aircraft. Certainly, parachutes as used on military bombers cannot be readily acceptable for schedule air carrier operation, except, perhaps, as an emergency.

I might cite an excellent example of the penalty incurred by high approach and landing speed. The runway length limitation of a certain airport in our system permits us to operate our DC-3 equipment, which stalls at 70 m.p.h. with a 200 ft. ceiling and $^1/_2$-mile visibility, whereas we must have at least a 300-ft. ceiling and a $^3/_4$-mile visibility with our four-engined equipment that stalls at substantially higher speeds. Thus, a 50 per cent penalty in ceiling and visibility is incurred because of a 16 per cent increase in stall speed, to say nothing of the cancellations due to such limitations, in spite of better flight characteristics.

Obviously, we cannot continue to buy runway length and approach zone rights indefinitely and remain solvent. The time has come when the aircraft must fit the available ground facilities designed to use them today.

It is commonly known that jet propulsion power plants are seriously affected by any rise in ambient air temperature. While afterburning as a means of thrust augmentation for take-off produces the largest thrust increase and the weight of the fuel required will probably not be taken as a part of the aircraft gross weight, yet it is felt that the lesser efficient water-methanol injection system may be more desirable because of its lower cost, lesser noise, reduced operating temperatures, and the fact that it does not reduce the effective flight fuel capacity.

The lower oil consumption of the gas-turbine engine should permit the design of virtually crashproof oil tanks as integral parts of the engines and, perhaps, automatically inerted beyond a certain deceleration. Stainless steel as a material for the oil tank and oil lines is the preferred material. Good design may thus remove one of the major fire feeders as a source of fire propagation.

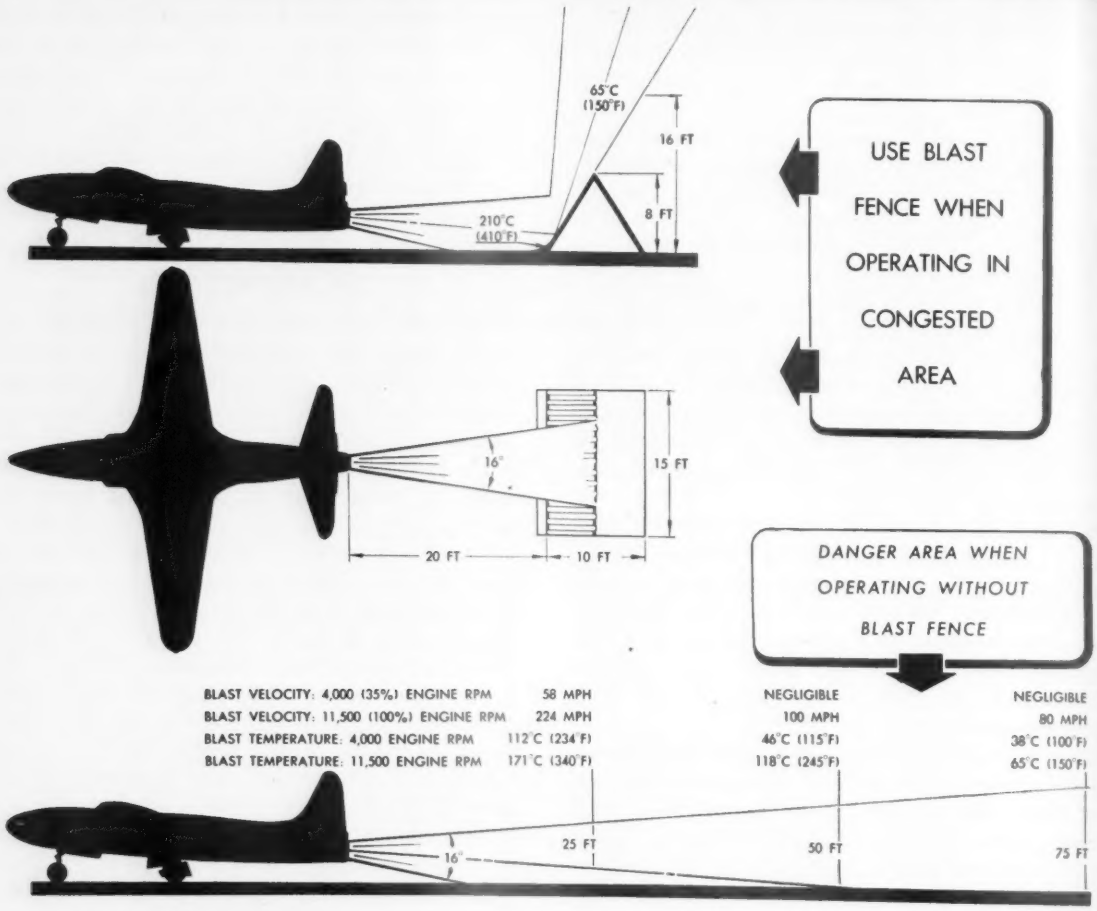
The second aircraft fire feeder, the engine fuel, which is by far the most potent because of its large quantity aboard, requires that fuel tanks be located so that in case of a crash the fuel cannot come in contact with potential ignition sources. This means that fuel should be carried in the wings outboard of the engines and possibly in wing-tip tanks. At least the fuel reserves should be so located that, when specific fuel consumption is reduced, such tanks can easily be removed. This is where the designer can use his ingenuity. He can, for instance, locate his engines aft and below the fuselage in a position to give excellent protection for the passengers, or he can locate them in pods that can be sheared off in case of sudden impact.

Underwing refueling will become universal because it is quick, needs no special ground equipment, eliminates personnel hazard, and prevents damage to the wing surface, so critical with laminar flow associated with high-speed aircraft.

There should be no fuel stored in the fuselage belly, if possible, and certainly none should be above the cabin floor regardless of possible protection. I know this is a difficult problem to solve because high speed requires thin wings and thin wings have relatively little capacity available for fuel storage. I also know that this is a perfectionist's view, a perfectionist being, according to Lindsay Rogers, a man who has no solution for any difficulty but is, nevertheless, able to find a difficulty in any proposed solution.

It serves to emphasize that the key to the success of jet propulsion as applied to aircraft is better fuel economy, and no stone should be left unturned to get it. The design of a satisfactory fuel to fit the gas turbine chemically and thermally is a knotty problem. We want low vapor pressure to eliminate fuel losses with rapidly changing flight altitudes, and, at the same time, we want to retain the safety feature of gasoline at high altitude.

Hydraulic fluid has been another major element causing disastrous aircraft fires. Much effort has been


65°C (150°F)
16 FT
8 FT
210°C (410°F)
USE BLAST FENCE WHEN OPERATING IN CONGESTED AREA
16°
15 FT
20 FT
10 FT
DANGER AREA WHEN OPERATING WITHOUT BLAST FENCE
BLAST VELOCITY: 4,000 (35%) ENGINE RPM 58 MPH NEGLIGIBLE NEGLIGIBLE
BLAST VELOCITY: 11,500 (100%) ENGINE RPM 224 MPH 100 MPH 80 MPH
BLAST TEMPERATURE: 4,000 ENGINE RPM 112°C (234°F) 46°C (115°F) 38°C (100°F)
BLAST TEMPERATURE: 11,500 ENGINE RPM 171°C (340°F) 118°C (245°F) 65°C (150°F)
16°
25 FT
50 FT
75 FT

Courtesy Lockheed Aircraft Corporation

FIG. 11. Airport ramp protection for jet tailpipe wake.

expended to develop fireproof material to replace it, but so far success has not been completely achieved. It would seem that greater attention should be paid to the development of pneumatic systems for the actuation of flaps, landing gear, brakes, and other means requiring power for their actuation.

Air is light, noncombustible, and free, whereas the newer chemicals to replace our present hydraulic fluids are expensive and heavier.

In the matter of power-plant fire-extinguishment means, we should reappraise the merits of methyl bromide versus CO_2, particularly as applied to jet propulsion engines. The high fire-fighting efficiency of methyl bromide and its low weight are important advantages that may well balance out its toxicity. It is odd that methyl bromide should be used almost exclusively in Europe, whereas we have virtually standardized on CO_2.

If water-methanol injection is used as a means of thrust augmentation, cabin pressurization obtained by bleeding from the turbine compressor will not be permissible, and mechanical or electrical means will need to be used.

Air inlets should be protected against the ingestion of water, snow, and slush, mud, or stones that may be thrown rearward by the landing-gear wheels. Their location should be such as to minimize the possibility of swallowing birds in flight.

Jacketing the tailpipe appears to be the most feasible way of providing the necessary heat for deicing and cabin heating.

There is little information available on ground-operating procedures to be followed with jet aircraft except as may be had for the military services. A consolidation of service experience on engine starting load requirements, taxiing procedures, and engine checking before take-off would be most useful.

The air-line and airport engineers need data on pressure, velocity, and temperature distribution of the jet tailpipe wake in order to study the airport ramp layouts and the provisions to be taken for the facilities and personnel (Fig. 11). Such data should be available in relation to specific thrust in order to be readily applicable to various engine sizes. It should be available for conditions of engine idling and taxiing and also at maximum take-off power in order to study the effects on runway surface materials.

Velocity and pressure patterns at the air inlet are needed to determine the hazardous areas to be avoided

during any servicing that may be accomplished while the engines are running.

Positive means must be provided in duplicate to indicate visually whenever the engines are in operation.

In the design of passenger cabins and to provide maximum safety in case of serious impact, we should take advantage of the high tolerance of the human body to high rates of deceleration when the impact load can be evenly distributed over the body area, including the head, by introducing rearward facing seating.

With jet transports flying high, the sense of direction is not readily detected because of lack of reference points, except during take-off and landing. It can be compared to being in a closed elevator moving at a constant rate, wherein it is practically impossible to determine whether the car is moving up or down unless the rate of movement is changed.

The time to implement rearward seating to save weight and cost is at the inception of the design, so that seats and structures can be properly correlated to absorb a deceleration rate up to 20*g* or 25*g* without excessive weight penalty.

It has also been advanced that bumps and noise may be less noticeable when riding backward, and thus may further reduce airsickness. This brings up the subject of gust alleviation means for high-speed operation and to obtain minimum ride roughness. Much remains to be learned about flying in the troposphere before regular passenger flights can be scheduled at 30,000 to 35,000 ft. Meteorological observations so far collected at these altitudes indicate that, while flight smoothness is prevalent, at times gusts are more severe than those experienced at the lower altitudes, and provisions must be made to alleviate the effects of such gusts not only on the passengers but on the structures as well.

It is axiomatic that, as we design air-frame structures surrounding the passenger cabin and its seating to increase their crash resistance, we proportionally decrease pay load, and a point will be reached where the cruising speed increase permitted by higher landing speeds will require an empty-weight increase that will reduce pay load to a point where the ton-miles of pay load per hour or transportation efficiency of the aircraft will begin to decline for equal accident safety. In other words, a balance must be reached structurally between pay load and safe performance.

As aircraft fly faster, it is becoming mandatory to institute a greater degree of functional order in the cockpit. With instrument-approach and landing systems becoming accepted standards, we must rearrange the aircraft cockpit instrumentation and controls, bearing in mind that the pilot is a human being with mental reflexes that cannot be changed. They can be trained to a certain degree, but their fundamental physiology cannot be altered. Here, science with simplicity could readily be applied.

The problem of visibility pertaining to the ability to see other aircraft becomes serious at the higher speeds. We must develop some artificial means that will enable the flight crew to have a continuous view of the danger area while scanning the flight and navigation instruments without having to move their eyes to cover the entire area.

High fuel consumption of jet power plants presents many airport problems. Airways control cannot depend on present means but must have instrumentation that will absolutely, unfailingly, and accurately follow the assigned aircraft flight patterns.

Airport stacking cannot remain ordinary procedure lest jet transports run out of fuel. The best way to correct this condition is again to reduce specific fuel consumption. Stacking is a matter of endurance rather than range and, because of jet engine characteristics, must be accomplished at as high an altitude as possible.

Airport approach and landing procedures must be readjusted to permit rapid descent in flight altitude and landing to obtain best economy. This may mean separation of jet transport flying from other flying until such time as jet propulsion as a power plant is universally applied for transport operation.

Present Civil Air Regulations call for a margin of 20 per cent between descent speed and dive speed. Perhaps this particular regulation should be re-examined for jet-powered aircraft application, since the turbojet becomes rapidly uneconomical with lower speeds. Would it not be better to predicate descent speed on compressibility effect and buffeting speed rather than select an arbitrary ratio as now prevails? Jet-powered aircraft should fly at as high a Mach Number as the effects of compressibility drag will permit. A balance must, of course, be reached between the maximum speed permitted by structural strength and maximum aerodynamic speed limited by compressibility effect.

Wing design is, today, following two design trends: (1) The straight wing, if not too highly tapered, has the advantage of providing good stalling characteristics. This is most desirable from the air transport point of view, although the price to be paid for it is lower maximum speed. (2) The swept wing creates aeroelasticity problems and poor control and stall characteristics if too highly swept, but it permits speeds approaching Mach 1. The swept wing also appears to have better gust alleviation characteristics, because the gust does not strike the entire wing span at the same instant.

That portion of the Civil Air Regulations dealing with temperature accountability will have a salutary influence on jet-powered aircraft design in that the rate of jet-engine power loss is approximately twice that of piston engines with increase of ambient temperature. Thrust augmentation can offset this disadvantage to some degree, but it is hoped that this characteristic of the jet engine will serve to limit wing loadings to reasonable figures consistent with safe operation on available runway lengths.

A Civil Air Regulation that requires revision is the one dealing with the direction of opening of cabin doors. With increased pressurization rates, it would seem desirable to have sliding doors that can readily be opened in

case of emergency. Such doors are pressure-sealed and, therefore, do not depend on latches and cannot be opened inadvertently.

Conclusion

While I have tried in this paper to outline some of the obvious problems that must be solved to apply successfully the principles of jet propulsion to transport aircraft for commercial operation, I am sure that I have missed many important ones. However, the principles of evaluation remain the same, and the basic fundamentals of transportation are not changed—just modernized.

There is no question that the application of jet propulsion to the airplane and the helicopter will profoundly change air transportation from what it is today. The solution of the problems they involve will provide stepping stones to the future progress of our dynamic industry.

To operate an air line at a profit should not be a miracle and *is not* a miracle when good common-sense management and engineering are practiced.

It has been said that difficult things are done today and that the impossible takes a little longer. Let's not take too long!

Aircraft Propulsion

(*Continued from page 32*)

With respect to engine component icing protection, the use of cyclical deicing for the inlet guide vanes rather than continuous heating will permit a saving of about 25 per cent of the total engine power requirements. The use of a hot-gas system requires a much larger heat supply from a given source than an electrical system. This larger heat requirement is caused by the inefficient heat transfer associated with hollow ducts inside the various components. Marked savings in the order of 50 per cent in heat input can be accomplished by the use of inserts, fins, and partitions in the hollow components.

The speaker then presented total heat loads for all the aircraft components and showed that the peak load occurred at an altitude of 15,000 ft. for the hot-gas system, requiring 7,500,000 B.t.u. per hour, of which 4,500,000 B.t.u. per hour represents the external heat load. The remainder of the hot gas represents a loss, indicating an efficiency of 60 per cent for a hot-gas system. The electrical system, on the other hand, peaks at an altitude of 25,000 ft. and requires only 960,000 B.t.u. per hour.

A discussion of possible heat sources showed that heat can be extracted from a turbojet engine in the following ways: (1) at the compressor outlet; (2) at the turbine inlet or outlet; (3) shaft power that can be converted to electrical power; and (4) by use of a tailpipe heat exchanger. In addition, various types of auxiliary power units may be used.

The tailpipe heat exchanger requires a fan or pump to pressurize the heated air before ducting to the various components. It is therefore no longer considered in the analysis as a heat source because of the weight additions and complexity of the system. Air bled from the turbine inlet or from the tailpipe requires mixing with outside air in order to decrease the gas temperature to the limits of the heating system (350°F.). This mixing can be accomplished with a jet pump.

Mr. Chandler then discussed the effect of the heat load required for icing protection on the aircraft performance with the various heat sources. By using air from the compressor outlet (10 per cent from each engine being required to furnish 7,500,000 B.t.u. per hour), the net thrust at 15,000 ft. is reduced 22 per cent. The remaining heat sources cause an approximate 4 per cent decrease unless bleed-back of the hot gas for injection into the airstream ahead of the engine is considered. In the latter case, a 12 per cent loss in thrust occurs. Shaft power extraction causes the least penalty, the decrease in thrust being less than $^1/_2$ per cent. Similar trends occur for specific fuel consumption, which is increased 22 per cent if compressor bleed is used.

A weight increase that must be compensated for by a corresponding decrease in pay load is evident with all heating systems. If the decrease in pay load is plotted as a function of anti-icing time in per cent flight time for each system, curves such as are shown in Fig. 3 result. It is apparent that, for short encounters with icing, the hot-air or -gas systems require the least decrease in pay load. For longer icing encounters in the order of 15 per cent of the flight time, shaft power extraction appears to be comparable to the tailpipe bleed system. The use of auxiliary power units requires the same ducting weights as the tailpipe bleed system plus the additional weights of the units.

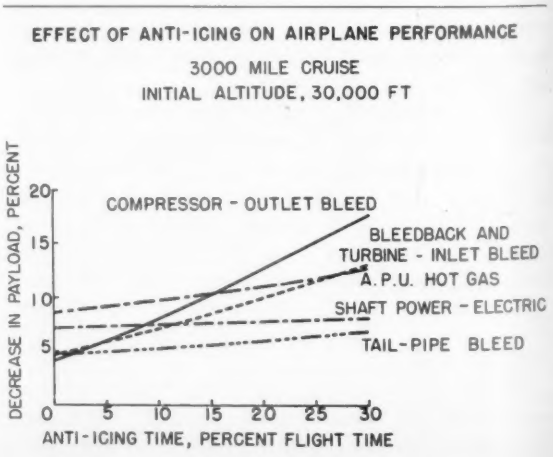


Fig. 3.

I.A.S. Briefs

Summaries of current papers accepted for publication or presentation at I.A.S. Meetings

Methods in Transient Stress Analysis

By

R. L. Bisplinghoff, G. Isakson, and T. H. H. Pian

Massachusetts Institute of Technology

A general method of approach to the problem of determining transient stresses in damped and undamped elastic structures is outlined. Methods for the approximate treatment of continuous elastic structures are discussed. The formulation of the problem is based on Lagrange's equation of motion and the use of displacements of natural modes of vibration as generalized coordinates. Two methods are found suitable for solving the equations of motion of the transient problem. The first is an application of the Laplace transformation which has been extensively used in the solution of transients in electrical systems. The second employs the principle that the transient response to an arbitrary forcing function can be expressed in terms of the response to sinusoidal forcing functions. The response due to a sinusoidal forcing function is defined as the mechanical admittance. Two methods of approach for determining the stresses corresponding to the deformation in an elastic structure are outlined. In the first, the stress is considered to be a superposition of the stresses corresponding to displacements of each of the normal modes. The stresses in each mode are calculated by using the inertia loadings associated with the natural vibrations. In the second, the total transient stress is considered as the sum of the stresses which would result if the system were restrained against vibrating and the additional stresses that result from the vibratory motion.

Crankshaft-Propeller Vibration Modes as Influenced by the Torsional Flexibility of the Engine Suspension

By

B. M. Fraeys de Veubeke

Civil Aeronautics, Brussels-Haren, Belgium

The present investigation is concerned with the fact that crankshaft-propeller torsional oscillations are coupled to the torsional oscillations of the engine as a whole. The basic phenomenon was discussed by Den Hartog and Butterfield in the elementary case of a single radial engine with a single resonant frequency on the suspension.

A general method of calculation is presented for long crankshaft engines. It is an extension of Biot's method, where, in addition to the usual dynamic moduli at both crankshaft ends, the solution contains the dynamic modulus of the engine suspension plus air frame with respect to the harmonic torque exerted by the crankcase.

Please do not order Preprints of these papers at this time.

See page 47 for Preprints that are immediately available.

Electrical Analog Solution for Centrifugally Tuned Pendulum Absorber System

By

James E. Anderson and Walter W. Soroka

Douglas Aircraft Company, Inc., and University of California at Berkeley

The response of a two-mass free-wheeling dynamical system to sinusoidal excitation as determined experimentally by means of a simple electrical analog corresponds closely over a wide frequency range with theoretically predicted amplitudes for the mechanical system. The analog was extended to include a hypothetical engine-propeller system equipped with a centrifugally tuned pendulum absorber and subjected to several orders of engine excitation. The responses experimentally determined by this means agreed satisfactorily with theoretical calculations for both cases, with and without the absorber, for all harmonic orders present.

Plastic Collapse and Shakedown Theorems for Structures of Strain-Hardening Material

By

B. G. Neal

Brown University

In recent years attempts have been made to develop methods of design for redundant structures of ductile material which are based upon the calculation of the load at which a structure actually collapses as a result of excessive plastic deformation. Such methods of plastic or limit design may be used when it is known in advance that all the loads on the structure will be applied simultaneously. However, when a structure is subjected to several loads, each of which may vary independently of one another, a different type of failure must be considered. As the loads vary, a cycle of plastic deforma-

tions may be established, even though no possible combination of the loads could cause collapse. In this case, failure would occur either (1) by the fracture of some member in which plastic deformations occurred alternately in one sense and then in the other or (2) by the development of excessive plastic deformation as a result of a finite increase in the amount of plastic deformation occurring during each cycle of loading. It is therefore necessary to ensure that, as the loads vary, the structure attains a state of residual stress such that no further plastic flow can occur, no matter how often and in what order the loads are repeated. When this occurs, the structure is said to have shaken down.

Recent theoretical work on the problems of plastic collapse and shakedown has been restricted to the case of trusses and framed structures whose members exhibit the ideal-plastic type of stress-strain relation. In the present paper, some theorems concerning collapse and shakedown are established for trusses and framed structures whose members possess a strain-hardening type of characteristic. The most interesting cases, which are covered by the theorems, are those in which the strain hardening is limited, so that the stress-strain characteristic eventually becomes horizontal and plastic deformation can continue indefinitely under constant stress.

The method adopted for the proof of these theorems is to simulate the strain-hardening characteristic by imagining a large number of bars of ideal-plastic material to be placed in parallel and constrained to have the same elongation. In this way theorems are established which are closely analogous to those that apply to structures of ideal-plastic material and which are in a suitable form to enable plastic collapse and shakedown loads to be calculated.

A Sharp-Focusing Schlieren System

By

Arthur Kantrowitz and Robert L. Trimpi

Cornell University

The conventional schlieren system, employing a parallel beam of light, is unable to distinguish between the density gradients occurring at various positions along the light path. The image formed by such a system thus represents the integrated effects of all the density gradients across the region under investigation, as well as the other sections of the light path, such as glass walls and air outside the region of investigation. In many cases it would be desirable to obtain an image in which density gradients in a given plane determine the image obtained—i.e., a sharp-focusing schlieren system.

A schlieren system with multiple sources and corresponding cutoffs has this sharp-focusing property. Each source-cutoff combination produces an independent schlieren image, and, for a given screen position, only the shadows produced by density gradients at a single plane in the flow superpose exactly. In general, for planes out of focus, offset superposition of the images blurs out the effects of density gradients not in the focal plane by a process similar to the focusing of ordinary lenses. In its present state of development the sharp-focusing schlieren system is not entirely effective near opaque walls parallel to the optical axis—e.g., for boundary-layer studies—since only grazing rays can be utilized in this case.

The performance of a model sharp-focusing schlieren system is illustrated by a series of photographs of a jet and a flame positioned along the optical axis. It is shown that photographs can be taken of the jet undisturbed by the presence of the flame and vice versa. A series of photographs of a normal shock wave in a nozzle are shown and compared with a conventional schlieren photograph.

Some of the more important problems in construction and adjustment are discussed.

The Incompressible Boundary Layer with Pressure Gradient and Suction

By

Leon Trilling

Northrop Aircraft, Inc.

This paper presents a generalization of the Blasius series to a boundary layer with arbitrary pressure and suction distribution. By transforming the boundary-layer equations from the physical x,y-plane to the x,u-plane, one formulates the problem as a single nonlinear parabolic partial differential equation with given initial and boundary conditions. This equation is solved approximately, and a new method is shown for finding the stability threshold. Three special examples are given: the Blasius boundary layer, the Schlichting boundary layer, and the boundary layer along the upper surface of a laminar flow airfoil at an angle of attack. In particular, a suction distribution is constructed to give completely stable flow over the positive pressure gradient region of the airfoil.

A Method for Improving the Inherent Stability and Control Characteristics of Helicopters

By

R. H. Miller

Massachusetts Institute of Technology

The problem of helicopter control and stability is examined with a view to establishing whether satisfactory inherent stability and control characteristics may be achieved without major design modifications and without having resources to automatic control devices. It is shown that the possibility does exist of improving both the damping and the static stability of a helicopter by a relatively minor modification of the blade mass and aerodynamic characteristics, together with the use of spring and viscous restraint in the control system. This should result in considerably improved blind flying characteristics and a reduction in excessive control sensitivity without sacrificing maneuverability. The control characteristic of such an inherently stabilized helicopter is evaluated by means of the transient response characteristics to abrupt control manipulation.

The Shearing Rigidity of Buckled Sheet Panels

By

Bruno A. Boley

Goodyear Aircraft Corporation

A formula giving the effective shearing rigidity of either flat or curved panels in the buckled state is developed from approximate theoretical considerations making use of the concept of effective width. Cases of panels buckled by compression, shear, or combined compression and shear are considered. The formula contains an experimentally determined exponent and gives values both for an effective shear modulus to be used in determinations of stress distributions and for a reduced effective shear modulus to be used in instability calculations. An experimental check is established.

I.A.S. Preprints

Preprints of I.A.S. Meeting Papers Currently Available

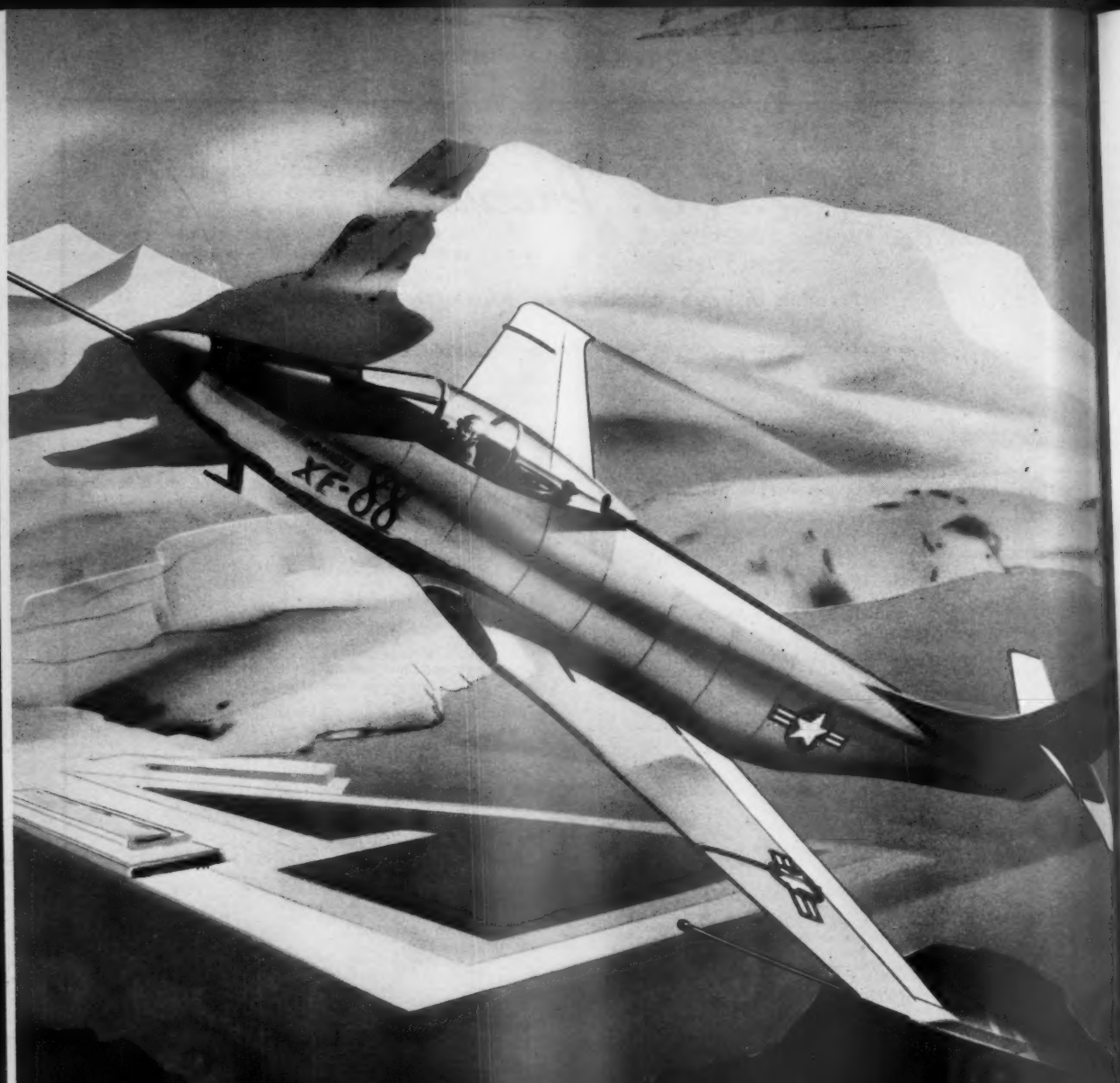
(All produced in accordance with new format except those marked with an asterisk)*

		Member Price	Nonmember Price
282	Propeller Turbines in Transport Aircraft—William C. Keller.	$0.35	$0.75
281	Turbine-Powered Transport Development—R. D. Kelly and Frank Davis.	0.35	0.75
280	Propulsion Analysis for Long-Range Transport Airplanes—A. Kartveli.	0.35	0.75
279	Optimum Performance of Rocket-Powered Missiles—Allen E. Puckett.	0.35	0.75
278	Design Refinements in Modern Propellers—Thomas B. Rhines.	0.35	0.75
277*	Do We Need Turboprops?—E. V. Farrar and R. E. Johnson.	0.35	0.75
275*	Fire Out—by Design—H. L. Hansberry.	0.35	0.75
274*	Maintenance of Safety Attitudes in Air Transport Operation—Robert Knight.	0.35	0.75
273*	Lateral-Control Devices Suitable for Use with Full-Span Flaps—F. M. Rogallo, John G. Lowry, and Jack Fischel.	0.35	0.75
267	Acoustic Measurement of Airstream Parameters—Victor B. Corey.	0.35	0.75
266	A Note on Crash Worthiness—William I. Stieglitz.	0.50	0.75
265	Progress in Fire Prevention—Following Crash—Lewis A. Rodert.	0.35	0.75
264	A Recurrence-Matrix Solution for the Dynamic Response of Elastic Aircraft—John C. Houbolt.	0.50	0.75
263	A Mechanical Analogy for Hypersonic Flow—H. Reese Ivey.	0.35	0.75
262	Design and Operational Features of the Sikorsky 1,000-Hp. Helicopter Rotor Test Stand—Harry Jensen.	0.35	0.75
261	Kinematic Behavior of the Human Body During Crash Deceleration—E. R. Dye.	0.35	0.75
260	The Influence of Design Parameters on the Performance of Subsonic Air Inlets—Howard E. Roberts and B. D. Langtry.	0.35	0.75
259	Analysis of the Elastic and Plastic Stability of Sandwich Plates by the Method of Split Rigidities—P. P. Bijlaard.	0.65	1.00
258	Types of Inelasticity of Structural Materials and Procedures of Design—Alfred M. Freudenthal.	0.50	0.75
257	An Initial Approach to the Overall Structural Problems of Swept Wings Under Static Loads—E. F. Sechler, M. L. Williams, and Y. C. Fung.	0.35	0.75
255	The Gyroscopic Effect of a Rigid Rotating Propeller on Engine and Wing Vibration Modes—R. H. Scanlan and John C. Truman.	0.50	0.75
254	The Solution of Aeroelastic Problems by Electronic Analogue Computation—Jonathan Winson.	0.50	0.75
253	A System for the Excitation of Pure Natural Modes of Complex Structure—Robert C. Lewis and Donald L. Wrisley.	0.65	1.00
252	A Method of Determining Some Aerodynamic Coefficients from Supersonic Free-Flight Tests of a Rolling Missile—R. E. Bolz and John D. Nicolaides.	0.65	1.00
251	The Longitudinal Stability of Elastic Swept Wings at Supersonic Speed—Charles W. Frick.	$0.50	$0.75
250	The Rolling-Up of the Trailing Vortex Sheet and Its Effect on the Downwash Behind Lifting Wings—John R. Spreiter and Alvin H. Sacks.	0.65	1.00
249	On the Stability of Two-Dimensional Transonic Flows—Y. H. Kuo.	0.35	0.75
248	The Transient Temperature Distribution in a Wing Flying at Supersonic Speeds—Joseph Kaye.	0.65	1.00
247	Lift on Inclined Bodies of Revolution in Hypersonic Flow—G. Grimminger, E. P. Williams, and G. B. W. Young.	0.65	1.00
246	A Precision Omnidirectional Radio Range for the Terminal Area—Joseph Lyman and George Litchford.	0.35	0.75
245	A Type of Lifting Rotor with Inherent Stability—Kurt H. Hohenemser.	0.50	0.75
243*	Integrally Stiffened Structures—Paul Sandorff and G. W. Papen.	0.35	0.75
242*	The Calculation of Supersonic Downwash, Using Line Vortex Theory—Harold Mirels and Rudolf Haefeli.	0.35	0.75
241*	Investigation of Lateral Dynamic Stability in the XB-47 Airplane—Roland J. White.	0.35	0.75
237*	Predictions of Supersonic Airplane Performance—Harold Luskin.	0.35	0.75
236*	Analysis and Design of Stiffened Shear Webs—Paul H. Denke.	0.35	0.75
235*	A Summary of Flight Load Data Recorded in Tactical and Training Operations During the Period of World War II—Lawrence B. Reynolds.	0.35	0.75
234*	Theoretical Lateral-Stability Derivatives for Wings at Supersonic Speeds—Arthur L. Jones.	0.35	0.75
233*	Some Operational Aspects of Distance-Measuring Equipment in the Transitional Air Navigation System—J. Wesley Leas.	0.35	0.75
232*	The Development of a Course Line Computer for the Air Navigation System—Chester Watts and Francis Gross.	0.35	0.75
231*	Supersonic Tests of Conventional Control Surfaces on a Double Wedge Airfoil—Michael Pindzola.	0.35	0.75
230*	Gust Criteria for Airplane Design—E. A. Rossman.	0.35	0.75
224*	Automatic-Control Considerations for Turbojet Engines with Tailpipe Burning—Melvin S. Feder and Richard Hood.	0.35	0.75
223*	Analysis of Turbojet Thrust Augmentation Cycles—Bruce T. Lundin.	0.35	0.75
222*	Basic Studies on Flame Stabilization—Glenn C. Williams.	0.35	0.75
218*	The Choice of Pressure Ratio in Aircraft Gas Turbine Power Plants—C. Richard Soderberg.	0.35	0.75
217*	High-Pressure Applications of the Supersonic Compressor—John W. Blanton.	0.35	0.75

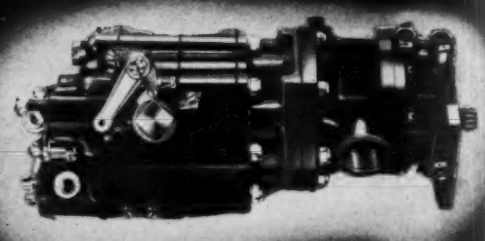
Preprints should be ordered by number from:

Preprint Department, Institute of the Aeronautical Sciences

2 East 64th St., New York 21, N.Y.



The 700-mile-per-hour Army XF-88—powered by a WESTINGHOUSE J-34 turbo-jet engine. THE TURBINE CONTROL for this engine is manufactured by HOLLEY.



HOLLEY Carburetor Co.

DETROIT 4

FOR HALF A CENTURY—ORIGINAL EQUIPMENT MANUFACTURERS FOR THE AUTOMOTIVE INDUSTRY.

Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

I. PERIODICALS AND REPORTS

The abstracts are classified according to the Air Technical Index Distribution Guide. Numbers in parentheses indicate the position of the Division Headings in the numerical arrangement.

Aerodynamics (2)
- Boundary Layer ... 50
- Control Surfaces ... 50
- Fluid Mechanics & Aerodynamic Theory ... 50
- Internal Flow ... 51
- Stability & Control ... 52
- Thermo-Aerodynamics ... 52
- Wings & Airfoils ... 52

Airplane Design & Description (10) ... 54
Airports & Airways (39) ... 56
Air Transportation (41) ... 56
Aviation Medicine (19) ... 56
Comfortization (23) ... 58
Education & Training (38) ... 58
Electronics (3) ... 58
Equipment ... 58
- Electrical (16) ... 58
- Hydraulic & Pneumatic (20) ... 58

Flight Safety & Rescue (15) ... 58
Flight Testing (13) ... 58
Fuels & Lubricants (12) ... 60
Gliders (35) ... 60
Guided Missiles (1) ... 60
Instruments ... 60
- Aircraft (9) ... 60
- Test & Measuring ... 60

Machine Elements (14)
- Bearings ... 60
- Fastenings ... 60
- Friction ... 60
- Gears & Cams ... 60
- Springs ... 60

Maintenance (25) ... 60
Materials (8)
- Metals & Alloys ... 62
- Nonmetallic Materials ... 62
- Protective Coatings ... 62
- Sandwich Materials ... 62

Meteorology (30) ... 62
Navigation (29) ... 62
Photography (26) ... 62
Power Plants ... 64
- Jet & Turbine (5) ... 64
- Reciprocating (6) ... 64
- Rocket (4) ... 65

Production (36) ... 65
Reference Literature (47)
- Yearbooks ... 65

Rotating Wing Aircraft (34) ... 65
Sciences, General (33)
- Mathematics ... 66
- Mechanics—Vibration ... 66

Space Travel ... 66
Structures (7) ... 66
Thermodynamics (18) ... 69
Water-Borne Aircraft (21) ... 69
Wind Tunnels (17) ... 69

II. BOOKS REVIEWED IN THIS ISSUE

Fundamentals of Aircraft Structures. Millard V. Barton ... 71
Reviewed by Dr. C. T. Wang, New York University

An Introduction to the Gas Turbine. D. G. Shepherd ... 71
Reviewed by R. P. Kroon, Westinghouse Electric Corporation

Principles of Aircraft Propulsion Machinery. Israel Katz ... 71
Reviewed by Kenneth Campbell, Wright Aeronautical Corporation

Book Notes ... **73**

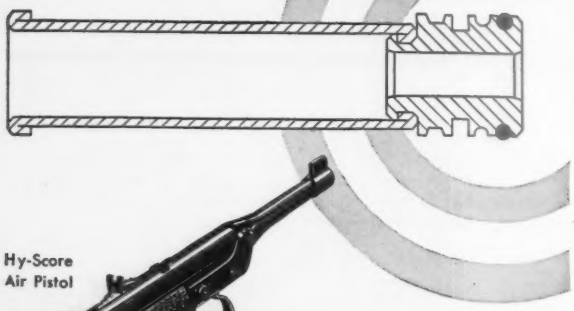
Books, reports, and periodicals reviewed in this issue or in previous issues may be borrowed on 2-week loan without charge by individual or Corporate Members of the Institute in the U.S. and Canada. Members of The Paul Kollsman Lending Library who are not Members of the Institute may borrow books and, in special cases, other research material. Members of the I.A.S. may borrow also from the Engineering Societies Library through The Paul Kollsman Lending Library.

Photostatic copies of material in the Institute's libraries may be obtained at a cost of $0.25 for each 8- by 10-in. print and $0.30 for each 10- by 14-in. print, plus postage. *Microfilm copies* on 35-mm. film can be supplied at $0.05 per frame; minimum charge—$1.00, plus postage. A service charge of $0.50 per item on photostat and microfilm orders is made to nonmembers of the I.A.S.

Bibliographies on special subjects will be compiled at the rate of $2.50 per hour. *Translations* of technical literature from foreign languages may be obtained at $12 to $14 per 1,000 words, depending on the language. I.A.S. members receive a 20 per cent discount on bibliographies and translations.

Full information about library membership and facilities will be sent upon request to The Paul Kollsman Lending Library, 2 East 64th St., New York 21, N.Y.

50% SAVINGS with LINEAR "O" RINGS



Hy-Score Air Pistol

with only a slight change in design!

Hy-Score Arms Corporation turned to LINEAR for a non-metallic seal capable of repeatedly withstanding pressures great enough to cause combustion of oil in a small air chamber. A saving of 50% was effected in the cost of the seal alone by changing to a LINEAR "O" Ring.* But, that's not the whole story! The LINEAR "O" Ring permits greater assembly tolerance in the manufacture of the piston parts resulting in further, substantial savings. Through such cost reductions, Hy-Score stays *on the target* for profitable production in more ways than one.

Thousands of products *throughout industry* are effectively and efficiently using economical, versatile, precision moulded LINEAR "O" Rings . . . for a host of sealing applications over a wide range of pressures and temperatures.

Compounded of natural or synthetic rubber for nearly every condition, LINEAR "O" Rings are also available in Kel-F, Silicone and other synthetics to resist the action of vigorous oxidizing materials at normal or extreme temperatures.

For individualized attention to your packing problem, design or application, Call LINEAR!

*The use of "O" Rings in certain packing structures is covered by Christensen Pat. No. 2,180,795 under which we have paid the royalty for the installation of our rings in these structures so that the royalty is included in the purchase price of the "O" Ring.

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILADELPHIA 35, PA.

Aerodynamics (2)

BOUNDARY LAYER

The Boundary Layer of Yawed Cylinders. W. R. Sears. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 117, 118. 1 reference. American Mathematical Society, New York.

The Boundary Layers in Fluids with Little Friction. H. Blasius. (*Zeitschrift für Mathematik und Physik*, Vol. 56, No. 1, 1908, pp. 1–37.) *U.S., N.A.C.A., Technical Memorandum No. 1256*, February, 1950. 57 pp., illus.

Readers' Forum: On the Surface Effects of a Compressible Laminar Boundary Layer. Arthur N. Tifford. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, pp. 187, 188, illus. 5 references.

The Numerical Solution of the Turbulence Problem. Howard W. Emmons. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 67–71, illus. 4 references. American Mathematical Society, New York.

Remarks on the Spectrum of Turbulence. C. C. Lin. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 81–86. 9 references. American Mathematical Society, New York.

CONTROL SURFACES

Aerodynamically Boosted Surface Controls and Their Application to the DC-6 Transport. Orville R. Dunn. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 503–530, Discussion, pp. 530–533, illus. 6 references.

Aerodynamic boost devices include aerodynamic nose-overhang balances and internal pressure balances on the main control surface and all types of tab control systems. All such boost systems are of a single general type, governed by a single set of equations. Only three basic linkage parameters are required to define a system. Equations developed for design analysis assume that the aerodynamic coefficients are linear functions of the angle of attack and surface deflections, and that the mechanical linkage characteristics are linear functions of the main surface, tab, and cockpit element motions. Hinge-moment data usually can be linearized with sufficient accuracy for design analysis, but certain types of surfaces, notably the Frise aileron, are not susceptible to linearization and require a simple graphic process. When, among other factors, its merits, limitations, costs, efficiency, and performance are considered, aerodynamic boost should produce satisfactory pilot forces on present transport aircraft, on high-speed aircraft at speeds up to Mach Number of approximately 0.95, and possibly at higher speed.

Lateral-Control Devices Suitable for Use with Full-Span Flaps. Francis M. Rogallo, John G. Lowry, and Jack Fischel. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 273.* 54 pp., illus. 41 references. Members, $0.35; nonmembers, $0.75.

Spoiler controls give high lift through the use of full-span flaps, good aileron effectiveness throughout the speed range, good yawing-moment characteristics, low wing torsional loads, and permit the use of low control forces. For high-speed airplanes they provide increased control effectiveness with speed, low hinge moments, and they lessen aeroelastic problems. Spoiler ailerons can be used as air brakes and can shorten the landing run. They offer flexibility of control, can be applied repeatedly, do not affect adjoining wing controls adversely, and should not cause tail buffeting on unswept wings.

Floating Characteristics of Rudders and Elevators in Spinning Attitudes as Determined from Hinge-Moment-Coefficient Data with Application to Personal-Owner-Type Airplanes. William Bihrle, Jr. *U.S., N.A.C.A., Technical Note No. 2016*, January, 1950. 67 pp., illus. 13 references.

FLUID MECHANICS & AERODYNAMIC THEORY

Local Isotropy in the Turbulent Wake of a Cylinder. A. A. Townsend. *Australian Journal of Scientific Research, Series A, Physical Sciences*, Vol. 1, No. 2, June, 1948, pp. 161–174, illus 8 references.

To investigate the validity of Kolmogoroff's theory of local isotropy, turbulence measurements were made in the wake of a circular cylinder of 0.953 cm. diameter, in an air stream of 1,280 cm. per sec.$^{-1}$ velocity. Measurements were made of the mean squares of the spatial derivatives in the mean-stream direction of the three components of the turbulent velocity fluctuation, and also of the skewness and flattening factor of the statistical distribution of those derivatives. Three traverses were made across the wake at distances equal to 80, 120, and 160 times the cylinder diameter downstream from the cylinder. Local isotropy exists in the turbulent wake, but allowance must be made for the intermittent character of the flow. The flow alternates irregularly between laminar and turbulent flow but within each patch of turbulent flow, local isotropy obtains. The theory is probably applicable to turbulent shear flow at high Reynolds Numbers.

The Velocity of Sound in Gases. R. L. Abbey and G. E. Barlow. *Australian Journal of Scientific Research, Series A, Physical Sciences*, Vol. 1, No. 2, June, 1948, pp. 175–189, illus. 20 references.

The velocity of sound in gases confined in a tube has been measured at a frequency of 1,000 cycles per sec., using a method based upon acoustical feedback. Measurements of the velocity were made at pressures ranging from atmospheric down to several millimeters of mercury for air, nitrogen, oxygen, carbon dioxide, and methane. The values obtained for the velocity at atmospheric pressure agree well with established figures, but the corrected velocity was found to vary with the pressure.

On a Family of Oblique Shock Curves. Edward R. C. Miles. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, pp. 157, 158, illus. 3 references.

The Pressure on a Slender Body of Nonuniform Cross-Sectional Shape in Axial Supersonic Flow. Ernest W. Graham. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, pp. 173–175, 192, illus. 4 references.

Readers' Forum: Base Pressures at Supersonic Velocities. Freeman K. Hill. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, pp. 185–187, illus. 6 references.

Readers' Forum: On the Vorticity of the Flow Behind Curved Shock. S. I. Pai. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, pp. 188, 189, illus. 3 references.

Readers' Forum: On the Compressibility Correction for Subsonic Unsteady Flow. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, pp. 181, 182. 3 references.

Readers' Forum: Upper and Lower Bounds on Variational Integral in Compressible Flow. G. V. R. Rao. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, p. 182. 3 references.

Readers' Forum: Boundaries of Fluid Mechanics. Keeve M. Siegel. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, pp. 191, 192, illus. 5 references.

Readers' Forum: Potential Flow Around a Rotating Cylindrical Blade. W. R. Sears. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, pp. 183, 184. 1 reference.

Polygonal Approximation Method in the Hodograph Plane. H. Poritsky. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 94–116, illus. 3 references. American Mathematical Society, New York.

Operator Methods in the Theory of Compressible Fluids. Stefan Bergman. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 19–40, illus. 21 references. American Mathematical Society, New York.

On Hamilton's Principle for Perfect Compressible Fluids. A. H. Taub. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 148–157. 5 references. American Mathematical Society, New York.

On the Stability of Two-Dimensional Smooth Transonic Flows. Y. H. Kuo. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 265.* 14 pp., illus. 12 references. Members, $0.35; nonmembers, $0.75.

By means of transonic approximations, a simple solution valid in the neighborhood of the sonic line was obtained in an investigation of the motion following the disturbance of a theoretically possible two-dimensional smooth transonic flow. The study leads to the conclusion that smooth transonic flows over symmetrical bodies are unstable to pulses with sufficiently long initial "wave lengths" and given "shock strength," and that flows over unsymmetrical bodies are stable to all pulses with arbitrary initial "shock strength" and "wave length," provided the slope of the body is positive at the deceleration-to-sonic point, if the body curvature is negative. The latter conclusion, although contrary to existing theories, has received partial support from certain limited experimental data obtained by the N.A.C.A. The critical Mach Number for observations of potential flow is defined on the basis of those stability criteria.

Lifting Surfaces in Supersonic Flow. I—Two-Dimensional Theory. Simon Ostrach. (Monograph No. 8.) *U.S., Air Force, Technical Report No. 102-AC49/7-100*, December, 1949. 59 pp., illus. 24 references.

Methods of Linearization in Compressible Flow. II—Hodograph Method; Supplement No. 1, The Transonic Flow Through a de Laval Nozzle. F. E. Ehlers. (Monograph No. 4.) *U.S., Air Force, Technical Report No. 102-AC49/5-100*, December, 1949. 61 pp., illus. 15 references.

The Method of Characteristics in Compressible Flow. I—Two Dimensional Flow with Large Entropy. J. A. Rockett and W. D. Hayes. (Monograph No. 2.) *U.S., Air Force, Technical Report No. 102-AC49/6-100*, December, 1949. 32 pp., illus. 3 references.

An Existence Theorem in Two-Dimensional Gas Dynamics. Lipman Bers. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 41–46. 15 references. American Mathematical Society, New York.

Two-Dimensional Compressible Flows. I. Opatowski. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 87–93. 18 references. American Mathematical Society, New York.

Non-Linear Problems in the Theory of Fluid Motion with Free Boundaries. Alexander Weinstein. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 1–18, illus. 36 references. American Mathematical Society, New York.

The Method of Characteristics in the Three-Dimensional Stationary Supersonic Flow of a Compressible Gas. N. Coburn and C. L. Dolph. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 55–66. 4 references. American Mathematical Society, New York.

On Shock-Wave Phenomena; Interaction of Shock Waves in Gases. H. Polachek and R. J. Seeger. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 119–144, illus. 26 references. American Mathematical Society, New York.

Theory of the Propagation of Shock Waves from Cylindrical Charges of Explosive. Stuart R. Brinkley, Jr., and John G. Kirkwood. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 48–54. American Mathematical Society, New York.

INTERNAL FLOW

The Influence of Design Parameters on the Performance of Subsonic Air Inlets. Howard E. Roberts and B. D. Langtry. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 260.* 14 pp., illus. 4 references. Members, $0.35; nonmembers, $0.75.

Wooden models of various inlet forms were tested in a closed-circuit wind tunnel in order to determine design characteristics for a subsonic air inlet to be located in the aircraft skin and to employ a boundary-layer bleed. Graphs and charts were made to show the influences of aspect ratio, protuberance, ramp profile, boundary-layer thickness, and bleed position upon the inlet total-pressure recovery, the critical Mach Number, and boundary-layer-bleed total-pressure recovery. The inlet total-pressure recovery is highest for inlet-velocity ratios near unity. In general, boundary-layer effects and the influence of ramp profile are greatest when protuberance is least—that is, for flush inlets. Recovery is best with the thinnest boundary layer and with the greatest bleed-velocity ratio. At different inlet-velocity ratios, different inlet components have the lowest critical Mach Number. Flush inlets, with long ramps and considerable ramp curvature,

have lower bleed recovery than semiflush and full-protruding inlets, and with a forward bleed position should give the highest bleed recovery.

Ordinates for Axially Symmetric Supersonic Nozzles. D. W. Lueck and Alexander J. Wang. *The Trend in Engineering*, Vol. 2, No. 1, January, 1950, pp. 26–28, illus. 3 references.

The semigraphical integration method proposed by Sauer is extended and employed for the determination of ordinates for axially symmetrical supersonic nozzles for Mach Numbers of 3.15 and 5.49. A comparison of those nozzle ordinates and others obtained by the more approximate method of Foelsch indicates that Sauer's method, although tedious, is the best practical approach to the theoretical flow condition. Reasonable care in graphical construction should enhance the accuracy of design by increasing the number of meshes in the final grid of Mach lines. Since the Mach net in the conical portion is a function of the expansion angle only, the publication of such data in tabular form should eliminate most of the labor involved in using Sauer's method.

Equations for the Design of Two-Dimensional Supersonic Nozzles. I. Irving Pinkel. *U.S., N.A.C.A., Report No 907*, 1948. 24 pp., illus. 2 references. U.S. Govt. Printing Office, Washington. $0.20.

Penetration of Air Jets Issuing from Circular, Square, and Elliptical Orifices Directed Perpendicularly to an Air Stream. Robert S. Ruggeri, Edmund E. Callaghan, and Dean T. Bowden. *U.S., N.A.C.A., Technical Note No. 2019*, February, 1950. 18 pp., illus. 2 references.

Compressibility Charts and their Application to Problems Involving Pressure-Volume-Energy Relation for Real Gases. A. V. Saharoff and H. M. Boteler. *Worthington Pump and Machinery Corp., Worthington Research Bulletin No. P-7637*, July, 1949. 25 pp., illus.

Charts of the compressibility factor which cover the broad range of pressure and temperature usually encountered in engineering practice provide data for the region adjacent to the low values of reduced pressure. The factor is plotted against reduced pressure for different values of reduced temperature, and the charts and formulas that are developed are applicable to gases that do not follow perfect-gas laws. The charts may be used for estimating compressor horsepower, limiting throat pressures, and weight flows through nozzles. They enable the engineer to obtain a better estimate of horsepower and weight flow requirements than is obtained by using ideal gas relationships.

Steady Flow of Nonviscous Elastic Fluids in Axially Symmetric Channels. M. H. Vavra. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, pp. 149–156, 172, illus. 7 references.

STABILITY & CONTROL

Investigation of Lateral Dynamic Stability in the (Boeing) XB-47 Airplane. Roland J. White. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, pp. 133–148, illus. 5 references.

Time-Dependent Downwash at the Tail and the Pitching Moment Due to Normal Acceleration at Supersonic Speeds. Herbert S. Ribner. *U.S., N.A.C.A., Technical Note No. 2042*, February, 1950. 17 pp. 15 references.

THERMO-AERODYNAMICS

The Transient Temperature Distribution in a Wing Flying at Supersonic Speeds. Joseph Kaye. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 248.* 31 pp., illus. 19 references. Members, $0.65; nonmembers, $1.00.

New problems in design for supersonic flight result from the large nonuniform temperature rise within the vehicle, the magnitudes of the thermal stresses, and the aerodynamic deflections caused by the nonuniform temperature distribution. The calculation of the transient temperature distribution is illustrated for the case of a thin wedge-shaped wing or airfoil subjected to constant acceleration from Mach Number 1.4 to Mach Number 6. A long and laborious numerical solution of the differential equation of heat flow in two dimensions with boundary conditions dependent on time indicates that the problem could be reduced to one-dimensional heat flow in the direction normal to the chord without sacrifice of accuracy, for a wing with maximum thickness ratio of less than 10 per cent, if the spanwise heat flow is assumed to be negligible. A shorter numerical method of solution for heat flow in one dimension, normal to the chord, yields temperature distributions that are in excellent agreement with those calculated by the two-dimensional heat flow method. The shorter method was used to investigate the effects of changes in the coefficients of heat transfer and in the acceleration values, and it was found applicable to the general case of a thin airfoil provided the variation of the local heat-transfer coefficient with time is available.

The Effects of Aerodynamic Heating and Heat Transfer on the Surface Temperature of a Body of Revolution in Steady Supersonic Flight. Richard Scherrer. *U.S., N.A.C.A., Report No. 917*, 1948. 10 pp., illus. 11 references. U.S. Govt. Printing Office, Washington. $0.15.

WINGS & AIRFOILS

Comparison Between Theory and Experiment for Wings at Supersonic Speeds. Walter G. Vincenti. *International Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 534–553, Discussion, pp. 553–555, illus. 15 references.

Experiment agrees well with theory for the lift-curve slope in the case of complete, three-dimensional wings when the mathematical problem is linearized by assuming thin wings, small angles of attack, and a perfect, inviscid gas. Results are less satisfactory for the moment-curve slope. For wings of given chordwise thickness distribution, the influence of plan-form variation upon minimum drag accords qualitatively with theory, but the drag increase for wings swept in the vicinity of the Mach cone is less than predicted. For triangular wings of double-wedge section, with fixed plan form and Mach Number, a forward movement of the chordwise position of maximum thickness failed to decrease the minimum drag as indicated by inviscid theory, because of an accompanying increase of turbulent boundary-layer flow. With the leading edge outside the Mach cone, the measured increase of drag was in reasonable agreement with theory, although results were not conclusive with regard to the attainment of forward force when the leading edge is within the Mach cone. On triangular wings of that type, however, forward displacement of the maximum thickness and subsequent rounding of the leading edge did have a measurably beneficial effect in reducing the drag due to lift and increasing the maximum lift-drag ratio.

The Rolling Up of the Trailing Vortex Sheet and Its Effect on the Downwash Behind Wings. John R. Spreiter and Alvin H. Sacks. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 250.* 34 pp., illus. 23 references. Members, $0.65; nonmembers, $1.00.

Theoretical and visual-flow methods were used to investigate the motion of the trailing vortexes associated with a lifting wing, in order to determine the proper vortex distribution to be used for downwash calculations. The degree to which the vortexes are rolled up depends upon the distance behind the wing and upon the lift coefficient, span loading, and aspect ratio of the wing. Although that vortex action is of little practical importance with conventional wings of moderate- or high-aspect ratio, the converse is true for low-aspect-ratio wings, in which case the trailing vortex sheet may become essentially rolled up into two trailing vortex cores within a chord length of the trailing edge. For the calculation of downwash in such cases, the assumption of a flat sheet of trailing vortexes is inadequate. A better approximation is to use a single horseshoe vortex and correct the result for the vertical displacement of the vortexes and for the finite diameter of the core.

The Characteristics of Supersonic Wings Having Biconvex Sections. Beverly Beane. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 271.* 45 pp., illus. 32 references. Members, $0.35; nonmembers, $0.75.

Wave drags of a representative series of thin wings of tapered plan form with multislope surfaces approximating the circular arc or biconvex section are computed by a generalization of the linear source-sink solution derived by Allen E. Puckett, and the solutions are compared with those for wings of double-wedge section. Experimental work on a limited number of wings gave drag values in satisfactory agreement with, or lower than, those predicted in the theoretical computations. The linear theory gives a reasonable first-order approximation of the characteristics of biconvex-section wings. For most applications the biconvex section is superior to the double-wedge section.

Every J & H Jet Starter must pass this and many other exacting tests before shipping.

J&H

JACK & HEINTZ

PRECISION INDUSTRIES, INC.
CLEVELAND 1, OHIO

You can depend on aircraft electrical equipment engineered, tested and produced by Jack & Heintz.

Charts for the Computation of Lift and Drag of Finite Wings at Supersonic Speeds. Ellis Lapin. *Douglas Aircraft Company, Inc., Report No. SM-13480,* October 14, 1949. 81 pp., illus. 12 references.

A series of charts that permit the relatively rapid determination of the lift, the drag due to lift, and the wave drag at zero lift for unyawed symmetrical wings of hexagonal plan form and with polygonal airfoil section at Mach Numbers in excess of unity. The charts cover a range of Mach Number and geometrical parameters sufficiently broad to include most swept wings of practical interest.

The Longitudinal Stability of Elastic Swept Wings at Supersonic Speed. Charles W. Frick and R. S. Chubb. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 251.* 23 pp., illus. 9 references. Members, $0.50; nonmembers, $0.75.

By the application of linearized lifting-surface theory, the longitudinal stability characteristics of elastic swept wings undergoing bending and torsional deformations were calculated for supersonic speed. The analysis was simplified by considering the wing panels to be simple cantilever beams and by assuming a parabolic wing deflection curve. Expressions were derived for the lift, pitching moment, and span-load distribution characteristics in terms of the elastic properties of a wing with leading edges swept behind the Mach lines. Comparison with matrix calculations for a wing with moment of inertia varying inversely with the fourth power of the spanwise dimension established the validity of the assumption of a parabolic deflection curve. Calculations made for subsonic speed showed that the aeroelastic characteristics are primarily a function of the flight dynamic pressure for wings that have subsonic leading edges at all flight Mach Numbers.

Low-Speed Investigation of a Thin, Faired, Double-Wedge Airfoil Section with Nose Flaps of Various Chords. Leonard M. Rose and John M. Altman. *U.S., N.A.C.A., Technical Note No. 2018,* February, 1950. 22 pp., illus. 2 references.

Theoretical and Experimental Data for a Number of NACA 6A-Series Airfoil Sections. Laurence K. Loftin, Jr. *U.S., N.A.C.A., Report No. 903,* 1948. 21 pp., illus. 5 references. U.S. Govt. Printing Office, Washington. $0.20.

An Experimental Investigation of the NACA 63_1-012 Airfoil Section with Leading-Edge and Midchord Suction Slots. George B. McCullough and Donald E. Gault. *U.S., N.A.C.A., Technical Note No. 2041,* February, 1950. 23 pp., illus. 2 references.

Readers' Forum: Lift-Curve Slope for Swept and Unswept Wings. Innes Bouton. *Journal of the Aeronautical Sciences,* Vol. 17, No. 3, March, 1950, p. 185.

Airplane Design & Description (10)

Aerodynamic Efficiencies of Large Landplanes. George S. Schairer. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings,* pp. 648–659, Discussion, p. 660, illus.

Pay load, range, speed, and operating cost, as expressed in the Breguet formula and others, determine the transportation value of the airplane and show the relative importance of design variables. Comparisons of the propulsive efficiencies and fuel-consumption rates of reciprocating, propeller-turbine, and jet engines give fuel utilization data, power-altitude characteristics, and the influence of those variables on power-plant weight. Factors determining the aerodynamic relationships, and the influence of design variables and of Mach Number upon lift-drag ratios and airplane weight are examined. Evaluation of power-plant efficiencies and combination of those factors with the aerodynamic factors show a marked superiority of the turbojet at high speeds and of the turboprop at low Mach Numbers, with a crossover point in the high subsonic speed range. Turbojet and turboprop airplanes are likely to be operated close to their buffeting limits, and adequate means must be developed for safely reducing the buffeting speed margin. The desire to fly at maximum altitude and speed conflicts with current design regulations, and that conflict must be resolved before commercial jet transports are built.

Aircraft Design Analysis. Ivan H. Driggs. *Royal Aeronautical Society, Journal,* Vol. 54, No. 470, February, 1950, pp. 65–106, Discussion, pp. 106–116, illus. 4 references.

Description of the methods of design analysis used by the Research Division of the Bureau of Aeronautics of the U.S. Navy. For the estimation of airplane performance, a double infinite slide rule is employed, which incorporates a control plate, a guide plate, and a power-required plate, each inscribed with scales and curves for altitude, weight, drag, power, and other parameters. It is used with charts and formulas to compute speed, power required, rate of climb, and range. This logarithmic analysis method is flexible and can account for all the variables that may be encountered in the performance analysis of any airplane. In estimating turbine-engine performance, the power plant is regarded as comprising a power-generating section and a propulsive section. By the use of enthalpy-entropy graphs the performance of the compressor and turbine can be estimated accurately in the design stage. A simple formula gives an efficiency factor for computing the power needed from the propulsion section of a jet, turbine-propeller drive, or combination aircraft, with or without thrust augmentation. The turboprop engine requires additional computations of the division of power between the jet and the shaft. The weight estimate is approached theoretically by the use of curves and data based on analysis of many types of U.S. military and commercial aircraft. Graphs, tables, and formulas permit the computation of the weight of major components.

Operating Factors Affecting the Design of Future Civil Transport Aircraft. Christopher Dykes. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings,* pp. 661–715, Discussion, pp. 715, 716, illus. 16 references.

A general survey of future transport operating problems, which refers particularly to an international scheduled air line using gas-turbine power plants and deals with cruising speed, timetables, aircraft utilization, ground facilities, passenger accommodations, weather conditions in flight, traffic-control, route analysis, and the use of "fixed sector fuel" and "minimum pay load" operating techniques. In general an aircraft must fit the task to be performed; the pay-load-range characteristics should always relate to the critical sector of the route, although not to the worst conditions thereon; the pay load for that critical sector should be adjusted to the needs of traffic producing the highest revenue—that is, passengers and mail; fuel capacity should be sufficient to reach alternate airports, even if pay load is reduced; and engine design must be adjusted to the critical conditions.

New Aeronca Champion (7EC). *Aviation Week,* Vol. 52, No. 10, March 6, 1950, p. 38, illus.

New Ideas in Austers; The Four-Seat Autocar, A New Military Auster and Some Autocrat Modifications. *The Aeroplane,* Vol. 78, No. 2016, January 27, 1950, pp. 98, 99, illus.

Superforts for Britain; A Round-Up of Essential Information on the Boeing B-29. *Flight,* Vol. 57, No. 2146, February 9, 1950, pp. 182, 183, illus.

Stratofreighter; Boeing's Pressurized Military Cargo and Personnel Transport. *Flight,* Vol. 57, No. 2142, January 12, 1950, pp. 48, 49, illus.

Building the Bristol Brabazon 1; A Review of the Various Stages of Construction. A. W. Morgan. *Airports & Air Transportation,* Vol. 4, No. 79, January, 1950, pp. 335–338, illus.

Convair B-36 Cutaway Sketch. *Aviation Week,* Vol. 52, No. 10, March 6, 1950, p. 13.

A New Spanish Aircraft (C.A.S.A. 201, Alcotan). *The Aeroplane,* Vol. 78, No. 2014, January 13, 1950, pp. 38, 39, illus., diagrs.

Beaver in the Air (D.H.C.2). *Flight,* Vol. 57, No. 2144, January 26, 1950, pp. 92, 93, illus., diagrs.

First Details of F3D Skyknight; Twin-Jet, Two-Place, High-Altitude, Navy Night Fighter. E. H. Heinemann. *Aviation Week,* Vol. 52, No. 10, March 6, 1950, pp. 23, 24, illus., diagr.

Eklund TE 1 (Finnish Single-Seat Amphibian). *Aviation Week,* Vol. 52, No. 7, February 13, 1950, p. 30, illus.

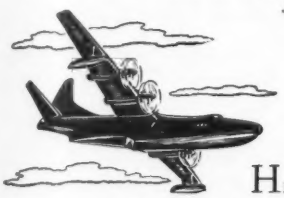
Britain's First Jet Bomber (English Electric Canberra B. Mk. 1.) *The Aeroplane,* Vol. 78, No. 2018, February 10, 1950, pp. 153–155, 160–162, illus.

Canberra: First British-Built Jet Bomber; Small Size and Short Range of Plane, While Having Little Utility by U.S. Standards, Fit England's Basic Needs. Robert McLarren. *Aviation Week,* Vol. 52, No. 7, February 13, 1950, pp. 21, 22, 24, 25, illus., diagrs.

Jet-Powered Sport Plane (Fouga Cyclone C.M. 8-R13). Paul H. Wilkinson. *Aero Digest,* Vol. 60, No. 2, February, 1950, pp. 24, 104–106, illus. Small airplane powered by a Turbomeca Pimene TR-011 jet engine.

Propulsive Power Plus—

for the Convair XP5Y-1

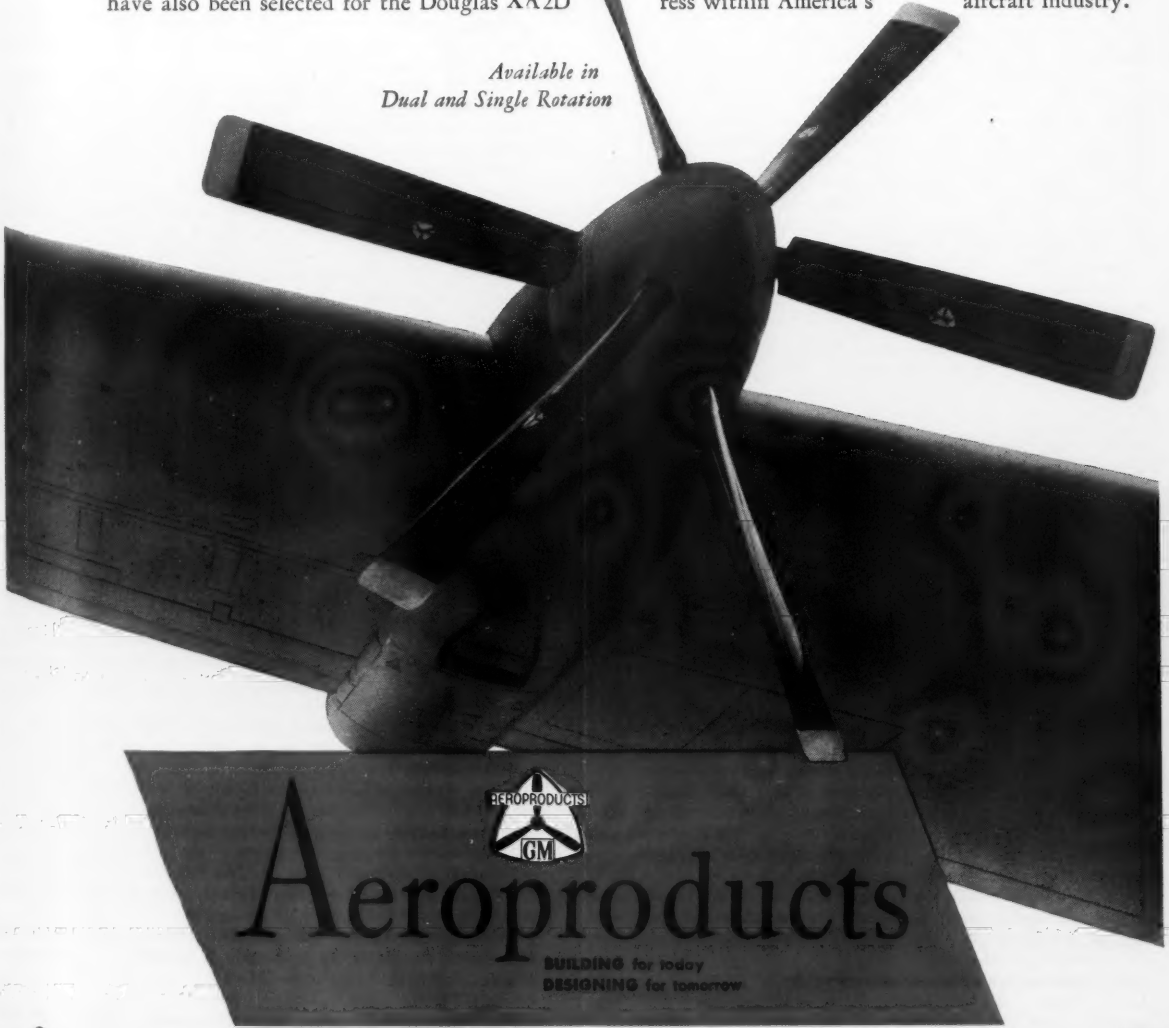


HERE IS THE LARGEST contra-rotating propeller now in final development stage. It is capable of efficiently converting the 5500 HP of the Allison T-40 turbine into propulsive power for this ultra-fast patrol plane.

Both propeller and controls have been tested for hundreds of hours on the T-40 turbine. In addition to being installed on the XP5Y-1, they have also been selected for the Douglas XA2D attack plane and the North American XA2J.

Today, governed by the Aeroproducts Electronic Turbo Propeller Control, the XP5Y-1 installation delivers more propulsive power per pound of airplane weight than many fighter planes receive. This program typifies what to expect from Aeroproducts—and General Motors Research—in working and planning for progress within America's aircraft industry.

Available in Dual and Single Rotation



AEROPRODUCTS GM

Aeroproducts

BUILDING for today
DESIGNING for tomorrow

AEROPRODUCTS DIVISION • GENERAL MOTORS CORPORATION • DAYTON, OHIO

GM GENERAL MOTORS

The World's Largest Prop-Jet Transport (Handley Page Hermes V). *The Aeroplane*, Vol. 78, No. 2014, January 13, 1950, pp. 40, 41, illus.

P.1052; Details of the Hawker Swept-Wing Experimental Fighter for High-Speed Research. *Flight*, Vol. 57, No. 2146, February 9, 1950, pp. 189–194, cutaway drawing.

Design 471. *Aeronautics*, Vol. 22, No. 3, February, 1950, pp. 42, 43, illus. Netherlands, three-wheel pusher, designed by H. Koekebakker.

France's Mystery Plane (Leduc 010). Oliver Stewart. *Flying*, Vol. 46, No. 3, March, 1950, pp. 22, 23, 57, illus.

Mignet the Undaunted; Unconventional-Aircraft Designer, Now in South America, Sings a New "Song of the Flea" (H. M. 300). A. R. Weyl. *Flight*, Vol. 57, No. 2143, January 19, 1950, pp. 64–66, illus.

The Mooney M-18L. Bob Arentz. *Flying*, Vol. 46, No. 3, March, 1950, pp. 30, 31, 54, illus.

The Survey Prince (Percival, P.54); Practical Features of a Specialist Aircraft, Unobstructed Camera Fields. *Flight*, Vol. 57, No. 2146, February 9, 1950, pp. 196, 197, illus.

Design Development of the Avro (C-102) Jetliner. J. C. Floyd. *The Engineering Journal*, Vol. 33, No. 1, January, 1950, pp. 18–30, illus.

Progress Report: Avro Jetliner (C-102). *Canadian Aviation*, Vol. 23, No. 2, February, 1950, pp. 25, 44, 46, illus.

The Development of the Saab-90 Scandia. Tord Lidmalm. *Aeronautical Society of India, Journal*, Vol. 1, No. 3, November, 1949, pp. 37–43, illus., diagrs.

In the design of a replacement for the DC-3 for medium-range transport service in Europe, it was decided that the safety requirements of the U.S. Civil Aeronautics Administration and of the International Civil Aviation Organization should be followed in full. Transport economy was sought through high pay load and high cruising speed. Simplified and standardized design and sturdy construction were employed for economical maintenance. Results of structural tests made for three different arrangements of the passenger and cargo loads agreed almost 100 per cent with the calculated values, and only slight modifications were needed after flight and service tests.

First Aerocar Flight Photos. *Aviation Week*, Vol. 52, No. 10, March 6, 1950, p. 14, illus.

Our Latest Aircrew Trainer (Vickers, Type 648, Varsity T. Mk. 1). *The Aeroplane*, Vol. 78, No. 2017, February 3, 1950, pp. 127–130, cutaway drawing.

New Russian High-Performance Jet Fighter (Yak-21). *American Aviation*, Vol. 13, No. 19, March 1, 1950, p. 14, illus.

Airports & Airways (39)

A Precision Omni-Directional Radio Range for the Terminal Area. Joseph Lyman and G. Litchford. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 246.* 12 pp., illus. 3 references. Members, $0.35; nonmembers, $0.75.

A technique to give greater accuracy in the measurement of angular position and to provide the necessary combination of angular and distance measurements for short-distance navigation aid and airport traffic control. A rotating antenna consisting basically of a triple-dipole element that produces a limacon radiation pattern within the confines of an omnidirectional wave-guide section. On the antenna shaft are mounted two generators, one producing a signal at 27.5 cycles per sec. and the other producing a signal at 302.5 cycles per sec. Those reference signals are impressed on a microwave carrier by a combination of frequency modulation and subcarrier techniques so that their phase is unaffected by amplitude variations due to the rotating antenna pattern. The signals may be separated easily in the aircraft receiver. To overcome the effects of ground transmission and multiple reflections, the spinning antenna is installed at the focal point of a cylindrical lighthouse lens that directs the signals into the proper distribution pattern. The new method provides angular accuracies of $\pm^1/_2$ degree or better, compared with the earlier limit of ± 3 degrees.

Navigational Systems and Instrument Aids. D. E. Adams and A. M. Uttley. *Airports & Air Transportation*, Vol. 4, No. 79, January, 1950, pp. 342–350, illus. (Extended summary of a paper.)

Solution to Airport Traffic Jams; New Omni Range System Shows Promise of Providing Fine Positional Accuracy Within 30-Mile Radius. *Aviation Week*, Vol. 52, No. 8, February 20, 1950, pp. 21, 24, 25, illus. 2 references.

DME is Top Navigational Need. Robert McLarren. *Aviation Week*, Vol. 52, No. 6, February 6, 1950, pp. 25, 28, 29, illus.

Analisis de Ayudas Radio Para Navegación. Luis de Azcarraga Perez-Caballero. *Revista de Aeronáutica* (Madrid), Vol. 9, No. 102, May, 1949, pp. 345–359, illus.

1013 And All That! F. Ormonroyd. *The Log*, Vol. 10, No. 2, February, 1950, pp. 40–43, illus.

Discussion of the problems of vertical separation of flight paths and suggestions for a flight-level indicator based on the altimeter.

Airports and Community Planning. Walther Prokosch. *Urban Land*, Vol. 9, No. 1, January, 1950, pp. 1, 3, 4.

The Airport Master Plan. J. B. Bayard, Jr. *Airport Operators Council, Second Annual Meeting, May 2–4, 1949, Report*, pp. 11–17.

For "Lighter" Landings; Recent Developments in Landing-Lamp Design, The Harley Range. *Flight*, Vol. 57, No. 2145, February 2, 1950, pp. 162, 163, illus.

Airports, Airlines Still Seek Equitable Charge Formula. Keith Saunders. *American Aviation*, Vol. 13, No. 18, February 15, 1950, pp. 18, 20.

London Airport Ground Traffic. I. II. *Flight*, Vol. 57, Nos. 2142, 2143, January 12, 19, 1950, pp. 40–44; 85–87, illus.

Air Transportation (41)

Some Economic Problems of Introducing New Types of Aircraft in Airline Operations. *Aeronautics*, Vol. 22, No. 3, February, 1950, pp. 24–26.

1955 Air Transport Reappraised from Engine Manufacturer's Viewpoint. D. J. Jordan. **Canadian Manufacturer's Viewpoint.** E. H. Atkin. **Airplane Manufacturer's Viewpoint.** Carlos Wood. **Airline Operator's Viewpoint.** H. R. Harris. *SAE Journal*, Vol. 58, No. 2, February, 1950, pp. 34–38, illus. (Extended abstract of a panel discussion: New Appraisal of 1955 Air Transport.)

Direct Operating Costs of Aircraft; S.B.A.C. Evolves Standard Method. *Modern Transport*, Vol. 62, No. 1607, January 14, 1950, p. 10.

The Effect of Jet Speeds on Air Line Schedule. I. II. S. T. B. Cripps. *The Aeroplane*, Vol. 78, No. 2017, 2018, February 3, 10, 1950, pp. 133–135; 163–166; illus.

The Problems of Public Skepticism and Fear as Related to Air Travel Advertising. Harold J. Littlefield. *New York University Graduate School of Business Administration, Master of Business Administration Thesis*, 1949. 49 pp. 55 references.

Air Cargo, 1950. Gerard E. Nistal. *Aero Digest*, Vol. 60, No. 2, February, 1950, pp. 34, 35, 100–104, illus.

Aviation Medicine (19)

Human Tolerance of Crash Deceleration. *Cornell University, Medical College, Cornell Committee for Air Safety Research, Crash Injury Research Project*, January 31, 1950. 6 pp., illus.

Tests made by means of a rocket-propelled rail car show that the human body can withstand accelerations greater than 35*g* without injury. In most cases, the interior structure of an airplane and its accessories give way at lower shock values, which indicates that structural strength is the limiting factor in pilot protection rather than the resistance of the body.

The New Human Centrifuge. R. L. Christy. *Journal of Aviation Medicine*, Vol. 20, No. 6, December, 1949, pp. 454–458.

The machine developed by the Office of Naval Research can attain a maximum acceleration of 40*g* in increments of 10*g* per sec. It has a 50-ft. radius, and the decompression chamber can produce simulated pressure-altitude conditions equal to 60,000 ft. at temperatures ranging from below 0° up to 200°F.

Hearing of Airline Pilots; A Ten-Year Study. Kinsey M. Simonton. *Journal of Aviation Medicine*, Vol. 20, No. 6, December, 1949, pp. 418–429, illus. 14 references.

Utilizacion de Oxigeno y Anhidrido Carbonico en los Vuelos de Alta Cota; Profilaxis de la Anoxia y Acapnia. Juan Forteza Bover. *Revista de Aeronáutica* (Madrid), Vol. 9, No. 98, January, 1949, pp. 23–26.

Protection Afforded the Cerebrovascular System by the Cerebrospinal Fluid Under the Stress of Negative *G*. Edward L. Beckman. *Journal of Aviation Medicine*, Vol. 20, No. 6, December, 1949, pp. 430–438, 442, illus. 8 references.

MID-CONTINENT AIRLINES

Serving the Heart of America

[illegible] 8TH AVENUE SO. MINNEAPOLIS 11, MINNESOTA

February 28, 1950

Surface Combustion Corporation
2375 Dorr Street
Toledo 1, Ohio

Attention: Mr. James W. Ashby, Sales Manager

Gentlemen:

To say that the installation of Janitrol package heaters in our DC-3 aircraft four years ago solved our major winter operation problem, is putting it mildly!

In fact, prior to the installation of Janitrol heaters, it was not uncommon for us to have the majority of our crews engaged in trying to keep the steam heating systems in operation during the winter months. However, upon installation of the Janitrol package heaters, the time spent in heater maintenance has been reduced to the point where it is of no consequence, and delays due to heater malfunctioning are rare, indeed.

Since converting from steam systems to Janitrol package heaters, our fleet has grown from 10 to 20 DC-3 aircraft, and our heater maintenance has been reduced to a fraction of the time required to maintain the steam systems. In addition, the ground heating provisions in our package heaters have contributed greatly to the comfort of our passengers in enabling them to board a comfortably-heated airplane during the coldest weather.

As you know, our route extends from Minot, North Dakota to southern terminals of New Orleans, Louisiana, and Houston, Texas. Despite such temperature extremes, the Janitrol heaters have proven themselves equal to all occasions.

Yours very truly,

MID-CONTINENT AIRLINES, INC.

C. W. CALHOUN
Vice President –
Engineering and Maintenance

"... putting it mildly"

Flying from deepest south straight north through the heart of America, you run into temperature extremes almost any day of the year. No wonder Mid-Continent Airlines is glad to have dependable heating all along the line *on a routine basis* . . . with its fleet of 20 DC-3s standard-equipped with Janitrol package heaters . . . Thanks, Mid-Continent, for your letter, and congratulations on your award for one of the industry's best safety records . . . Putting it mildly, we believe you'll continue to find "Janitrol heaters" an important item to write into aircraft specifications. Your nearest Janitrol representative is always at your service.

Janitrol

AIRCRAFT AND AUTOMOTIVE HEATERS *with the whirling flame*

AIRCRAFT-AUTOMOTIVE DIVISION • SURFACE COMBUSTION CORP., TOLEDO 1, OHIO

F. H. Scott, New York, N. Y., 225 Broadway; C. B. Anderson, Kansas City, Mo., 1438 Dierks Building; Lee Curtin, Hollywood, Calif., 7046 Hollywood Blvd.; Frank Deak, P. A. Miller, Central District Office, Engineering Development and Production, Columbus, Ohio; Headquarters, Toledo, Ohio.

Cybernetics and Aviation Medicine. Paul A. Campbell. *Journal of Aviation Medicine*, Vol. 20, No. 6, December, 1949, pp. 439–442. 4 references.

Toxic Gases and Civil Aircraft. C. R. Spealman. *Journal of Aviation Medicine*, Vol. 20, No. 6, December, 1949, pp. 448–453. 14 references.

Safe Parachute Descent—An Unsolved Problem. H. A. Smedal and A. P. Webster. *Journal of Aviation Medicine*, Vol. 20, No. 6, December, 1949, pp. 443–447. 5 references.

Comfortization (23)

Fluorescent Lighting for Aircraft. S. Anderson. *Osram Bulletin*, Vol. 27, No. 1, January, 1950, pp. 12–15, illus.

Super DC-3 Heating System; Control Simplicity Key to Comfort and Reliability. *Aircraft Heating Digest*, Vol. 1, No. 4, December, 1949, pp. 4, 5, illus.

Education & Training (38)

Synthetic Training. *The Aeroplane*, Vol. 78, No. 2016, January 27, 1950, pp. 96–97, illus. The Link C-11 jet-flight trainer.

Electronics (3)

A Royal Air Force Calibration Centre. W. H. Ward. *Institution of Electrical Engineers (London), Proceedings, Part III, Radio and Communication Engineering*, Vol. 97, No. 45, January, 1950, pp. 49–55, illus.

A Calibration Centre has been set up in the Royal Air Force to provide all aircraft and R.A.F. stations with electrical standards that are known to agree with each other. The paper discusses the general principles governing the design of the Centre and gives some details of the methods and apparatus used.

Radio for Light Aircraft. *Flight*, Vol. 57, No. 2143, January 19, 1950, pp. 75–79, illus.

Equipment

Driving Aircraft Accessories Remotely from the Aircraft Engine. H. R. Shows. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 15, No. 3, March 1, 1950, pp. 16–25, illus.

ELECTRICAL (16)

The Relative Merits of Auxiliary Power Systems—The Electrical Aspect. R. H. Woodall. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 439–472, illus. 23 references.

An examination of the electrical systems used on various British aircraft shows that their reliability, durability, accessibility, cleanliness, and ease of control offsets, in larger units, even the relatively slight weight advantage of hydraulic and pneumatic systems. Since electric power is available and is used in one way or another in most of the hydraulic and pneumatic systems, it should be utilized for all possible functions.

HYDRAULIC & PNEUMATIC (20)

The Relative Merits of Auxiliary Power Systems—The Case for Hydraulics. H. G. Conway. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 417–438, illus. 3 references.

Pneumatic systems compare unfavorably with hydraulic systems because of poor ratio of power, weight, and size. Hydraulic systems are superior in lubrication efficiency, corrosion resistance, low-temperature performance, provision for locking cylinders, the tracing of leaks, damping of rapid motion, flow control and division, motor operation, safety against explosions, and offloading to remove pressure during long flights. Electric is heavier than hydraulic equipment, it has poor mechanical adaptability and speed reduction, and its emergency actuation is slow and awkward. Objections to hydraulic equipment can be overcome by using nonflammable fluids, adequate drainage, proper pipe location, improved filtering and seals, and by the inclusion of special thermal-expansion relief valves. Hydraulic pressures ranging up to 4,000 lbs. per sq.in. or more can permit a still lower weight for the equipment and piping. Hydraulic actuation is currently employed in at least 95 per cent of the types of aircraft in service and in 99 per cent of the number of craft in use.

Highlights in the History of Machine Hydraulics. IV—Automatic Circuits. H. G. Conway. *Machine Design*, Vol. 22, No. 2, February, 1950, pp. 114, 115, illus.

Rotary Pistons Utilized in New Hydraulic Pump Design. Roger W. Bolz. *Machine Design*, Vol. 22, No. 2, February, 1950, pp. 116–118, illus., figs.

The Relative Merits of Auxiliary Power Systems—The Case for Pneumatics. H. R. Haerle. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 473–499, Discussion, pp. 499–502, illus.

The advantages of a compressed air aircraft auxiliary power system include the universal availability of air; its adaptability to a wide range of services; safety, because of the absence of flammable fluid; fewer, simpler, lighter, less vulnerable parts; suitability for rotary, and linear applications, rapidity of operation; and its cleanliness. Compressibility effects can be minimized by damping devices; efficiency can be improved by using higher pressures; leaks are not usually serious; and freezing can be prevented by injecting methanol vapor into the system or by removing moisture. Pressures have been increased to 3,000 lbs. per sq.in., and compressors, controls, and actuators have been improved. Pneumatic systems are well suited for emergency services, are completely reliable, can be integrated with other systems, and are readily installed, maintained, and repaired.

Notes on Pneumatics. II. Eugene Stolarik. *Aero Digest*, Vol. 60, No. 2, February, 1950, pp. 44–46, illus.

Flight Safety & Rescue (15)

Maintenance of Safety Skills and Attitudes in Airline Operation. Robert W. Knight. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 274.* 23 pp., illus. Members, $0.35; nonmembers, $0.75.

American Airlines' safety program, which includes safety inspections, meetings, bulletins, periodicals, visual and aural aids, motion pictures, and incentive programs.

A Note on Crashworthiness. William I. Stieglitz. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 266.* 18 pp., illus. 27 references. Members, $0.50; nonmembers, $0.75.

With particular attention to safety-belt and seat design for transport and military aircraft, analyses are made of Civil Aeronautics Board statistics on air-line accidents in the period 1938 through 1948. Protection against forces of 20*g* is the minimum recommended level of crashworthiness, and values up to 40*g* are desirable, with corresponding increases in protection against sideward and upward-acting forces. The weight penalty involved in providing the protection indicated need not be high and is less than for other emergency provisions. The economic value of reduced accident rates would greatly exceed the relatively small weight and cost factors entailed.

Fire Fighting and Crash Rescue at Small Airports. Jerome Lederer. *Aero Digest*, Vol. 60, No. 2, February, 1950, pp. 58, 97–99, illus.

Notas Sobre los Accidentes de Aviacion. Joaquin F. Quintanilla. *Revista de Aeronáutica* (Madrid), Vol. 9, No. 99, February, 1949, pp. 90–100, illus.

Organizacion del Auxilio en los Accidentes Aereos. Angel Garaizabal Bastos. *Revista de Aeronáutica* (Madrid), Vol. 9, No. 100, March, 1949, pp. 189–192, illus.

Flight Testing (13)

Flight Research at Transonic and Supersonic Speeds with Free-Falling and Rocket-Propelled Models. F. L. Thompson *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 582–596, Discussion, pp. 596, 597, illus. 4 references.

Investigations conducted by the N.A.C.A. with free-falling bodies were made primarily to determine the drag, in the transonic range, of the bodies and of wing-body configurations with wings at zero lift. With rocket-powered models, emphasis was placed on stability and control problems, as well as on drag. Flutter investigations have been made by both techniques. Free-fall tests of bodies with fineness ratio varying from 6 to 12 show that a body of fineness ratio of 12 has by far the least drag beyond

The new Sperry H-5 Gyro-Horizon features the fastest gyro *erection device* yet developed to help transports reduce ground time and gain flying time. The initial erection cycle is completed in 30 seconds after the main switch is turned on . . . permitting immediate take-off. This *advanced* artificial horizon promotes airline schedule reliability by thus expediting take-offs, saving valuable time on routine stops and turnarounds.

The erection device which makes this possible operates in conjunction with a small remote power control unit. Other design changes feature latest developments for increased reliability and longer service life. Improved dial with larger miniature airplane increases angle of vision 40% . . . giving the pilot clearer visibility, easier and more accurate readings of bank and pitch.

When the Gyro-Horizon is paired with the Sperry Gyrosyn Compass, the pilot gets *attitude* and *directional* indications he can rely on. Result . . . precise attitude and directional control regardless of visibility.

OTHER FEATURES OF THE H-5. Non-tumbling . . . no caging devices needed. Freedom of roll through 360 degrees. Gyro won't tumble even during a complete loop.

This new Gyro-Horizon is another example of Sperry's *advanced* research and engineering *timed* to today's *advanced* aviation service. Our Aeronautical Department will be glad to supply complete information.

SPERRY GYROSCOPE COMPANY

DIVISION OF THE SPERRY CORPORATION, GREAT NECK, NEW YORK • NEW YORK • CLEVELAND • NEW ORLEANS • LOS ANGELES • SAN FRANCISCO • SEATTLE

Mach Number 1.0, but its great length is a disadvantage in the subsonic range. Sweepback has marked advantages in reducing drag. In rocket-powered models, the effects of sweep far overshadow the effects of aspect ratio in obtaining low drag, if the wing is behind the Mach cone.

Determination of the Rate of Roll of Pilotless Aircraft Research Models by Means of Polarized Radio Waves. Orville R. Harris. *U.S., N.A.C.A., Technical Note No. 2023*, February, 1950. 22 pp., illus. 1 reference.

Fuels & Lubricants (12)

Lubrication of Metal Surfaces by Silicone Films. J. N. Gregory and Marjorie J. Newing. *Australian Journal of Scientific Research, Series A, Physical Sciences*, Vol. 1, No. 1, March, 1948, pp. 85–97, illus. 15 references.

Methods for the preparation of mono-, di-, and tri-isoamyl chlorsilanes, and the monocetyl chlorsilane have been developed. Molecular layers of the mono- and diethyl and mono- and di-isoamyl silicones on various metal surfaces have been tested for their boundary lubricating properties. The layers have been shown to be excellent lubricants, with unusual thermal stability and resistance to wear.

Comparative Foaming Characteristics of Aeronautical Lubricating Oils. W. W. Woods and J. V. Robinson. *U.S., N.A.C.A., Technical Note No. 2031*, February, 1950. 18 pp., illus. 1 reference.

Variation with Temperature of Surface Tension of Lubricating Oils. Sydney Ross. *U.S., N.A.C.A., Technical Note No. 2030*, February, 1950. 14 pp., illus. 6 references.

Foaming of Mixtures of Pure Hydrocarbons. J. V. Robinson and W. W. Woods. *U.S., N.A.C.A., Technical Note No. 2032*, February, 1950. 19 pp., illus. 3 references.

Rise of Air Bubbles in Aircraft Lubricating Oils. J. V. Robinson. *U.S., N.A.C.A., Technical Note No. 2033*, February, 1950. 24 pp., illus. 4 references.

Lubricants for Aviation Gas Turbines. C. S. Windebank. *Esso Air World*, Vol. 2, No. 4, January, 1950, pp. 90–94, illus.

Gliders (35)

The Czech Lunak (L-107). *Soaring*, Vol. 13, Nos. 11, 12, November–December, 1949, pp. 8, 9, illus.

Guided Missiles (1)

Supersonic Guided Missiles. II. R. E. Gibson. *American Rocket Society, Journal*, No. 79, December, 1949, pp. 155–165.

Solid-fuel rockets excel in simplicity, performance reliability, and expendability, and their field of usefulness is becoming broader in such applications as auxiliary propulsion for guided missiles. They are suitable also for the main propulsion system of short-range supersonic missiles, although liquid-fuel rockets and ram-jets are preferable for intermediate and long ranges. An explanation of the principles of ram-jets, their diffusers, and combustion processes shows that the attainment of optimum overall efficiency, as measured by the thrust coefficient, depends on matching the diffuser and the combustion chamber and operating with minimum losses.

Guided Missiles. A. K. Wickson. *The Engineering Journal*, Vol. 32, No. 12, December, 1949, pp. 815–819, illus.

An explanation of the fundamental principles of propulsion, guidance, and control, and of the aerodynamic aspects of guided-missile design and use.

Anglo-Australian Long Range Weapon Project. L. J. Carter. *British Interplanetary Society, Journal*, Vol. 9, No. 1, January, 1950, pp. 1–5, illus. 1 reference. Woomera rocket-firing range, Adelaide, Australia.

Instruments

The Theory of Symmetrical Crossed Flexure Pivots. W. H. Wittrick. *Australian Journal of Scientific Research, Series A, Physical Sciences*, Vol. 1, No. 2, June, 1948, pp. 121–134, illus. 2 references.

AIRCRAFT (9)

Acoustic Measurement of Airstream Parameters. Victor T. Corey. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 267*. 11 pp., illus. Members, $0.35; nonmembers, $0.75.

A direct approach to the accurate measurement of the Mach Number, the true air speed, and the true air temperature of air streams which makes use of velocity of sound. Mach Number is measured by the ratio of a variable distance to a fixed distance; true air speed by the ratio of the same variable distance to the acoustic transit time between emitting and receiving transducers. Over a large range of conditions the acoustic transit time varies only with the true air temperature and may therefore be used to measure that variable. Measurements over a wide range of speeds in a subsonic wind tunnel were found to agree closely with concurrent measurements by conventional methods. It is expected that sufficiently satisfactory transducers can be constructed and that acceptable discrimination against air-borne and air-generated noises can be achieved to permit measurement of those three parameters throughout the subsonic and well into the supersonic velocity ranges, in wind tunnels, and on aircraft in flight.

TEST & MEASURING

Effects of Low Temperatures on Electric Strain Gages. E. E. Day. *The Trend in Engineering*, Vol. 2, No. 1, January, 1950, pp. 10–13, illus.

Machine Elements (14)

BEARINGS

Friction and Wear of Hot-Pressed Bearing Materials Containing Molybdenum Disulfide. Robert L. Johnson, Max A. Swikert, and Edmond E. Bisson. *U.S., N.A.C.A., Technical Note No. 2027*, February, 1950. 27 pp., illus. 8 references.

Maintenance of Antifriction Bearings. J. M. Bruening. *Mechanical Engineering*, Vol. 72, No. 2, February, 1950, pp. 142, 143.

Characteristics of Greases as Related to Antifriction Bearing Applications. E. S. Carmichael and R. C. Robinson. *Mechanical Engineering*, Vol. 72, No. 2, February, 1950, pp. 137–141, 143, 144, illus. 5 references.

Housing and Spindles for Antifriction Bearings. H. L. Blood. *Mechanical Engineering*, Vol. 72, No. 2, February, 1950, pp. 131–133, illus. 1 reference.

FASTENINGS

Torque Capacity of Bolted Couplings. W. R. Leopold. *Machine Design*, Vol. 22, No. 2, February, 1950, pp. 151, 152, illus.

FRICTION

Investigation of Fretting Corrosion by Microscopic Observation. Douglas Godfrey. *U.S., N.A.C.A., Technical Note No. 2039*, February, 1950. 31 pp., illus. 9 references.

GEARS & CAMS

Effect of Axis Angle on Tapered Gear Design. George Sanborn and Ben Bloomfield. *Product Engineering*, Vol. 21, No. 2, February, 1950, pp. 129–132, illus.

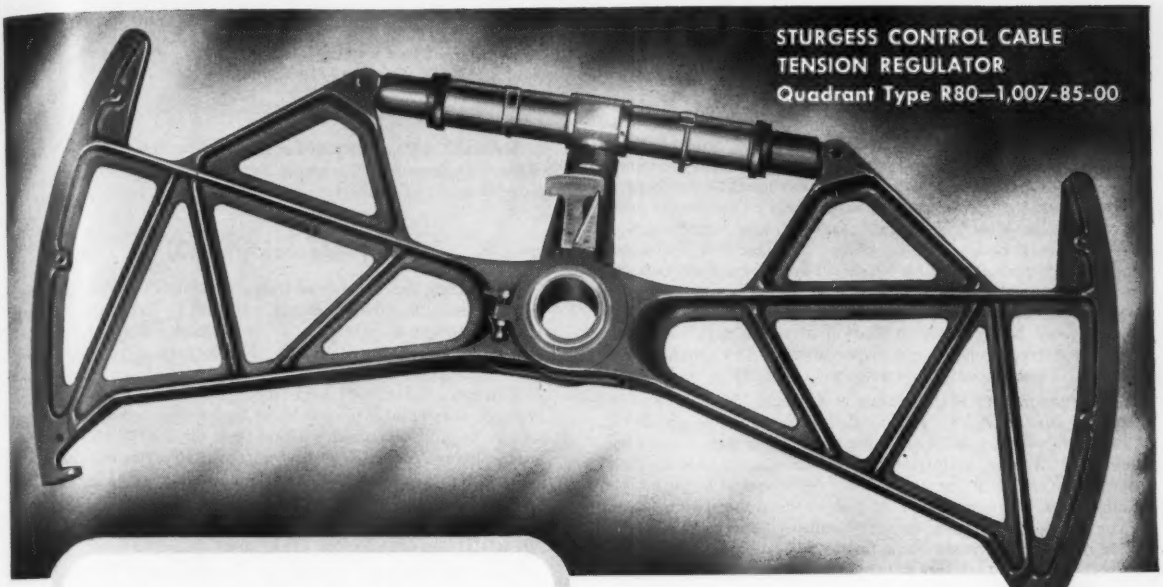
SPRINGS

Simplified Design Procedure for Helical Wire Springs. August J. Kwossek. *Product Engineering*, Vol. 21, No. 2, February, 1950, pp. 140–143, illus.

Fundamental design equations and equations that contain parametric constants depend on the diameter and physical properties of the spring wire. Constants for seven spring materials are included.

Maintenance (25)

Utilization Factors and Maintenance of Civil Aircraft. Warren E. Alberts. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 717–737, illus.



Do STURGESS REGULATORS actually improve flight control and safety?

YES...They prevent slack cables and erratic control due to extreme cold, and, prevent increased tension and friction due to high temperatures. They prevent over-taut or over-loose cables due to structure distortion caused by heavy loads or cargo placement. And Sturgess Regulators make possible the use of reduced tensions resulting in greater ease in handling.

Can STURGESS REGULATORS be installed in existing aircraft?

YES...there are standard units available which can be easily installed to operate at top efficiency, the size and type being determined by the requirements of the individual control system.

Where should STURGESS REGULATORS be used?

In both Primary and Secondary cable installations particularly in planes subject to severe stress due to load, speed or temperature changes. The design requirements will determine which type can be used most effectively. Units developed to date include sizes from 4 to over 36 inches in diameter.

How many types of STURGESS REGULATORS are there?

There are two general types . . . STANDARD UNITS designed for existing control quadrants, sectors or drums or which can be mounted on stationary structures. BUILT-IN REGULATORS...designed as an integral part of a quadrant, sector, or drum mounting at either end of a control system. Functional requirements determine what style and size to use.

How long do STURGESS REGULATORS last?

They are designed and constructed as an integral part of the plane and with proper care and maintenance should last as long as any structural part. They have been tested in operation under all flight and temperature conditions from over 160° F. to −65° F., and have been delivering trouble free service on airline and military planes for years.

Are STURGESS REGULATORS economical?

YES...they eliminate the necessity of cable tension adjustments. They decrease pulley, pin and cable wear. They permit rigging at any time under any temperature conditions with the assurance that tensions will remain as rigged.

Read these questions and answers about maintaining

Constant Cable Tension in Your Aircraft

with STURGESS REGULATORS!

The need for constant control cable tension has become urgent with the advent of faster, higher ceiling and larger aircraft, which magnify the adverse effects of temperature, structure deflection and control system friction.

Sturgess Regulators maintain constant control cable tension under all flight conditions. Light in weight, self-contained, and entirely mechanical in operation, they insure the constant ease of control and instant rigid response to the pilot's slightest touch.

Sturgess Regulators are now being used constantly in many of today's finest aircraft.

If you have a problem of regulator installation in existing aircraft or planes in the design stage our engineers can help you. WRITE TODAY!

Pacific SCIENTIFIC CO.

1430 GRANDE VISTA, LOS ANGELES 23, CALIFORNIA
25 STILLMAN STREET, SAN FRANCISCO 7, CALIFORNIA

Improvement has been made in the utilization of that portion of a transport fleet's time cycle devoted to meeting or awaiting traffic demands by better scheduling of aircraft, by considering their operating capabilities, and by establishing central control of fleet routing in combination with an overall knowledge of system demand. Better ground handling and servicing have been achieved by simplifying operating procedures, improving the equipment and methods, and scheduling on a basis of maximum utilization of station manpower. Maintenance time and expense are being reduced by performing maintenance at the fewest possible points; by providing adequate facilities and a uniform work flow in units of equal size; by proper planning and man-power controls; by evaluating each operation on the basis of its necessity, frequency, and method; by developing simple tests to determine need for overhaul or removal; by inspections to reduce unpredictable failures; by utilization of production techniques and standard crews on periodic inspections; and by centralization of aircraft-routing control and inspection scheduling.

The Servicing and Maintenance of Aircraft. R. A. Fry. *The Technical Instructor*, Vol. 4, No. 12, December, 1949, pp. 7–15.

To effect a reduction of the time spent in servicing and overhauling an airplane, maintenance problems should be considered from the inception of the design. All parts should be accessible, standardized, and simplified. It is more economical to establish shorter service-life periods for parts subject to wear and fatigue and to replace them at stated intervals than to have piecemeal repair, expense, and time loss in keeping old parts in use until they fail. "Sealed servicing," done by the manufacturer and the air line, reduces running maintenance and releases skilled personnel for more productive work.

Boeing Service Guide, No. 28, January, 1949? 12 pp., illus. Model 377 Stratocruiser.

Passenger Aircraft Maintenance. *Airports & Air Transportation*, Vol. 4, No. 80, February, 1950, pp. 365–368, illus.

Materials (8)

METALS & ALLOYS

Compressive Properties of Titanium Sheet at Elevated Temperatures. Paul F. Barrett. *U.S., N.A.C.A., Technical Note No. 2038*, February, 1950. 10 pp., illus. 12 references.

Resistance of Six Cast High-Temperature Alloys to Cracking Caused by Thermal Shock. M. J. Whitman, R. W. Hall, and C. Yaker. *U.S., N.A.C.A., Technical Note No. 2037*, February, 1950. 29 pp., illus. 9 references.

Stress-Strain Relations for Strain Hardening Materials; Discussion and Proposed Experiments. D. C. Drucker. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 181–187, illus. 9 references. American Mathematical Society, New York.

Dislocation Theory of the Fatigue of Metals. E. S. Machlin. *U.S., N.A.C.A., Report No. 929*, 1949. 10 pp., illus. 26 references. U.S. Govt. Printing Office, Washington. $0.15.

NONMETALLIC MATERIALS

Glasscloth Ducting; Lightweight, High-Strength Units for Anti-Icing and Air-Conditioning Systems. *Aircraft Production*, Vol. 12, No. 136, February, 1950, p. 55, illus.

Numerical Methods in the Solution of Problems of Non-Linear Elasticity. Wilfred Kaplan. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 194–196, illus. American Mathematical Society, New York.

The Damping Capacity of Some Indian Timbers. D. Narayanamurti and B. N. Prasdad. *Aeronautical Society of India, Journal*, Vol. 1, No. 3, November, 1949, pp. 30–37. 5 references.

The Response Characteristics of Linear Systems. Marcello Cini. *Journal of Applied Physics*, Vol. 21, No. 1, January, 1950, pp. 8–10. 16 references.

For a linear system, steady-state response to sinusoidal stress cannot have a unique dynamic modulus and phase shift, but these quantities must be related to rate of creep; particularly, they cannot be independent of external frequency. A proof that such linear system is always equivalent to a viscoelastic system is compared with the experimental results of various authors.

PROTECTIVE COATINGS

Silicone Surface Coatings. M. A. Glaser. *Product Engineering*, Vol. 21, No. 2, February, 1950, pp. 109–111, illus.

SANDWICH MATERIALS

Mechanical Properties of Laminated Plastics. *U.S., National Bureau of Standards, Technical Report No. 1409*, February, 1950, 8 pp., illus. 2 references.

Meteorology (30)

Forecasting the Heights of Cumulus Cloud-Tops on the Washington-Bermuda Airways Route. Harold L. Crutcher, James C. Hunter, Robert A. Sanders, and Saul Price. *American Meteorological Society, Bulletin*, Vol. 31, No. 1, January, 1950, pp. 1–7, illus. 7 references.

A numerical index of vorticity at 700 mb. is obtained from synoptic maps and is shown to be highly correlated with the observed heights of cumulus cloud-tops on the Washington-Bermuda airways route. The usefulness of this relationship in forecasting is supported by tests made on independent data.

Forecasting the Height of Formation of Stratus Clouds. Frank Gifford, Jr. *American Meteorological Society, Bulletin*, Vol. 31, No. 2, February, 1950, pp. 31–37, illus. 14 references.

Upper Air Average Values of Temperature, Pressure, and Relative Humidity over the United States and Alaska. *U.S. Weather Bureau, Technical Paper No. 6*, April, 1949. 104 pp., illus. (Reprint.)

The Temperature Distribution of the Upper Atmosphere over New Mexico. Alex Nazarek. *American Meteorological Society, Bulletin*, Vol. 31, No. 2, February, 1950, pp. 44–50, illus. 11 references.

Atmosfera Superior. Joaquin Catala de Alemany. *Revista de Aeronáutica* (Madrid), Vol. 9, No. 103, June, 1949, pp. 419–428, illus. 1 reference.

Atmospheric Pressure Changes, The Importance of Deviations from the Balanced (Gradient) Wind. C. H. B. Priestley. *Australian Journal of Scientific Research, Series A, Physical Sciences*, Vol. 1, No. 1, March, 1948, pp. 41–57, illus. 14 references.

Translation and Development in Two-Dimensional Fields, with Special Reference to Pressure Variations. R. W. James. *Australian Journal of Scientific Research, Series A, Physical Sciences*, Vol. 1, No. 4, December, 1948, pp. 412–422. 3 references.

Condiciones Meteorológicas del Vuelo Estratosférico. A. Torralba García. *Revista de Aeronáutica* (Madrid), Vol. 9, No. 104, July, 1949, pp. 516–522, illus.

El Avión en la Exploración Aerológica y la Localizacion de Turbulencias Permanentes. Ricardo Munaiz de Brea. *Revista de Aeronáutica* (Madrid), Vol. 9, No. 100, March, 1949, pp. 179–184, illus.

Navigation (29)

Generalización del Empleo de Círculos de Altura Astronómica. Jose M. Aymat. *Revista de Aeronáutica* (Madrid), Vol. 9, No. 101, April, 1949, pp. 255–260, illus.

Can We Slow Down the Lightplane? R. G. Naugle. *Flying*, Vol. 46, No. 3, March, 1950, pp. 14, 15, 60, 61, illus.

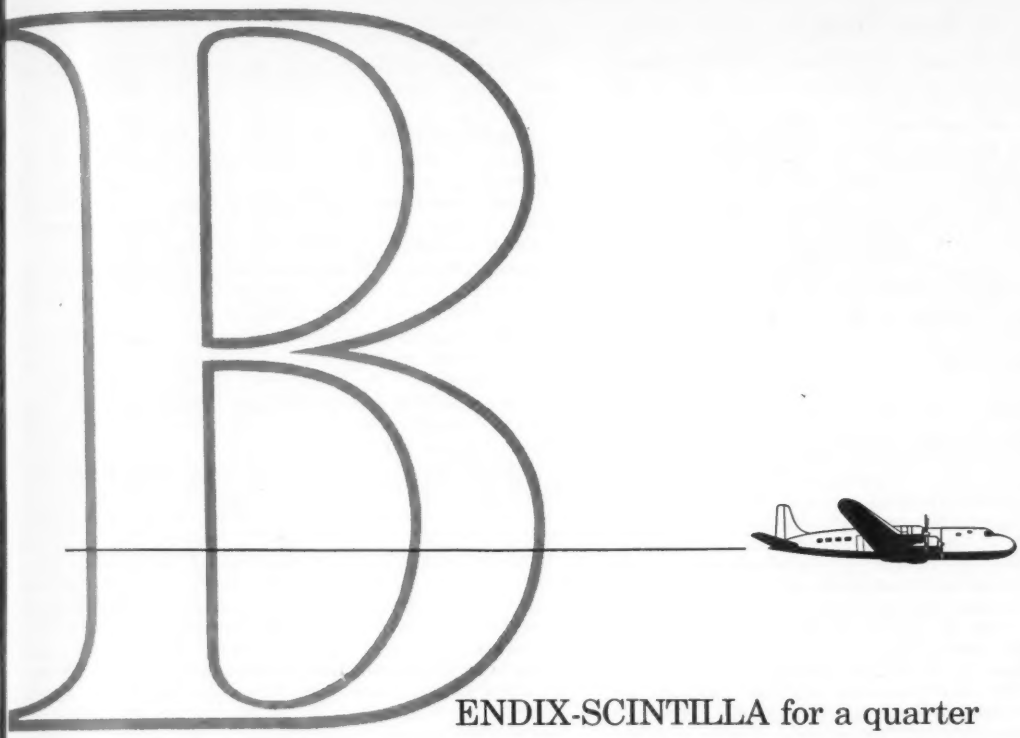
The Personal Airplane Outlook. *Western Flying*, Vol. 30, No. 2, February, 1950, pp. 8, 9, 17, illus.

Personal Flying—Why Not? Warren E. Carey. *Western Flying*, Vol. 30, No. 2, February, 1950, pp. 15, 16, illus.

Photography (26)

Memory Control. J. S. Goldhammer. *Machine Design*, Vol. 22, No. 2, February, 1950, pp. 107–110, illus.

A semiautomatic, lightweight, semiportable machine for developing and printing aerial photographs at the rate of 10,000 to 20,000 ft. per day, the Air Force type A-7 processing machine and D-1 printer, uses a photoelectric unit to regulate the degree of exposure in the printer according to the light density of the negative.



ENDIX-SCINTILLA for a quarter of a century has devoted its resources and engineering skill to the progressive development of *all types* of Aircraft Ignition. Thus, the aviation industry has come to consider Bendix-Scintilla the one source *uniquely qualified* to design and produce ignition equipment to meet every operating requirement.

When you plan with Bendix-Scintilla you are assured of ignition recommendations—whether Low Tension, High Tension, or High Frequency—that will be specifically designed to meet your requirements and to fulfill your needs for economy, performance, and dependability.

BENDIX SCINTILLA

SCINTILLA MAGNETO DIVISION of Bendix AVIATION CORPORATION

SIDNEY, NEW YORK

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N. Y.

Power Plants

The Military Aero-Engine—Is It Suitable for Civil Aviation? S. B. Bailey. *Royal Aeronautical Society, Journal*, Vol. 54, No. 470, February, 1950, pp. 121–125.

Comparison of the requirements for military and civilian aircraft engine shows that the attributes of reliability, economy, performance, and ease of maintenance are common to both fields. Certain military engines developed expressly for troop transport or reconnaissance should be suitable for use in civil aircraft, but attempts to modify engines designed primarily for fighters are not likely to be economical. Development of both types should be continued, so that in event of war the civil-aircraft engine would be available for military transport or bomber use.

Compound Engine Systems for Aircraft. E. J. Manganiello, L. V. Humble, and D. S. Boman. *SAE Quarterly Transactions*, Vol. 4, No. 1, January, 1950, pp. 79–92, illus. 18 references.

JET & TURBINE (5)

Turbine-Engined Transport Aircraft. George R. Edwards. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 89–162, Discussion, pp. 162–165, illus. 15 references.

An analysis of the development of British turbine power plants and transport aircraft, and a thorough comparison of available types of power units. An evaluation of performance factors, purchase price, costs of operation and maintenance, and installation problems favors the propeller-turbine power plant ordinary commercial services. From the passengers' standpoint, turbine-propeller units are safer than reciprocating engines because kerosene is demonstrably safer as a fuel than aviation gasoline. They are more comfortable because of the absence of vibration and the low noise levels. The absence of vibration stress results in less frequent overhaul and lower repair time and cost. Turbine overhaul periods soon will equal those of piston engines. Initial costs are not materially different for new aircraft with either turbine or piston engines. In direct operating cost the propeller-turbine airplane is more economical than a comparable piston-engined craft for ranges up to 1,000 miles. For ranges of 2,000 miles or more there is little to choose between the operating economics of the pure jet, turboprop, and compound reciprocating engine, and all three of those are more economical than the straight piston engine

Optimum Fields of Application for Air-Consuming Aircraft Power Plants. W. G. Lundquist and G. S. Kelley, Jr. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 9–18, Discussion, pp. 18–22, illus.

A method for determining the optimum-range power plant for various speed categories by evaluation of the relative utilization of the fuel energy by the different types of engine at various speeds. The best power plant for any particular application is the one that has the lowest losses. For subsonic applications the reciprocating and compound reciprocating engine will be dominant for many years. With further advancement in performance efficiency and mechanical durability, the turboprop power plant will ultimately supersede the piston engine for maximum range. Turbojet engines will dominate the upper subsonic, the transonic, and the lower supersonic fields. The ram-jet engine is unlikely to find practical application at speeds below 1,500 m.p.h. Power plants in the maximum-range categories also give the optimum engine orientation throughout the speed spectrum with regard to reserve power or thrust augmentation ratio.

Gas Turbines and Their Maintenance in Civil Aircraft. C. W. Rossiter-Smith. *Aeronautical Society of India, Journal*, Vol. 1, No. 3, November, 1949, pp. 1–30, illus.

Summary of the operating principles and features of British gas-turbine power plants for jet and propeller transport aircraft; descriptions of the ignition, starting, fuel and lubrication systems, and field and shop maintenance, overhaul, repair, installation, and testing procedures. Specific maintenance and inspection schedules for the Dart, Mamba, and Theseus engines are listed in appendixes.

Turboprop Controls. George P. Knapp. *Aero Digest*, Vol. 60, No. 2, February, 1950, pp. 38, 39, 93–97, illus.

Turbojet Combustion-Chamber Problems. Stewart Way. *Aero Digest*, Vol. 60, No. 2, February, 1950, pp. 52–54, 56, 87, 88, illus. 2 references.

P & W Unveils 6250-Lb.-Thrust J-48. *Aviation Week*, Vol. 52, No. 10, March 6, 1950, pp. 15, 16, illus.

For Turbine Research; Pratt and Whitney Willgoos Laboratory. *Flight*, Vol. 57, No. 2142, January 12, 1950, pp. 52, 53, illus.

Ramjet Laboratory. *Aero Digest*, Vol. 60, No. 2, February, 1950, p. 26, illus. Wright Aeronautical Corporation, Wood-Ridge, N. J.

Wright Aero Pushes Ramjet Study. *Aviation Week*, Vol. 52, No. 6, February 6, 1950, pp. 21, 22, illus. Wright Aeronautical Corporation test installation at Wood-Ridge, N.J.

Small Turbines. *The Aeroplane*, Vol. 78, No. 2015, January 20, 1950, pp. 72, 73, illus. French Turboméca Piméné aircraft power turbine, Turboméca Orédon auxiliary turbine.

Type-Test of the Turboméca Piméné; Development of France's 220 lb.-Thrust Turbojet. *Flight*, Vol. 57, No. 2142, January 12, 1950, p. 53, illus.

Reply to Discussions of the Wright Brothers Lecture. A. E. Russell. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, pp. 176, 177.

Determination of Stresses in Gas-Turbine Disks Subjected to Plastic Flow and Creep. M. B. Millenson and S. S. Manson. *U.S., N.A.C.A., Report No. 906*, 1948. 16 pp., figs. 6 references. U.S. Govt. Printing Office, Washington. $0.15.

Surface Tension Diagnosed as Cause of Spray Nozzle Problems. Frank C. Mock and Dean R. Ganger. *SAE Journal*, Vol. 58, No. 2, February, 1950, pp. 22–25, illus. (Extended summary of a paper: Practical Conclusions on Gas Turbine Spray Nozzles.)

Extension of Useful Operating Range of Axial-Flow Compressors by Use of Adjustable Stator Blades. John T. Sinnette, Jr., and William J. Voss. *U.S., N.A.C.A., Report No. 915*, 1948. 28 pp., illus. 17 references. U.S. Govt. Printing Office, Washington. $0.20.

Blade Manufacture; A Concise Review of Current American Practice. A. T. Colwell, K. M. Bartlett, and R. E. Cummings. *Aircraft Production*, Vol. 12, No. 136, February, 1950, pp. 66–69, illus.

Impeller Blade Design for Maximum Strength with Minimum Weight. Harold Woodhouse. *Machine Design*, Vol. 22, No. 2, February, 1950, pp. 111–113, illus.

Development of a mathematical expression for obtaining the ideal radial profile of a blade to give minimum weight for a selected maximum tensile strength. It is generally applicable to blade sections of radial and mixed-flow compressor impellers and radial-flow turbine wheels.

Precision Sheet-Metal Parts; Manufacture of Assemblies for American Gas-Turbine Engines. W. C. Heath. *Aircraft Production*, Vol. 12, No. 136, February, 1950, pp. 58–62, illus.

Experimental Analysis of a Pressure-Sensitive System for Sensing Gas Temperature. Richard S. Cesaro, Robert J. Koenig, and George J. Pack. *U.S., N.A.C.A., Technical Note No. 2043*, February, 1950. 52 pp., illus. 6 references.

Some Factors in the Use of High Temperatures in Gas Turbines. I. T. W. F. Brown. *The Engineer*, Vol. 189, No. 4906, February 3, 1950, pp. 161, 162, illus. (Extended summary of a paper.)

RECIPROCATING (6)

Postwar Development of the Reciprocating Engine. F. J. Wiegand and E. H. Olson. *SAE Quarterly Transactions*, Vol. 4, No. 1, January, 1950, pp. 8–14, 23, illus.

Analysis of Stress in Aircraft Engines. William T. Bean, Jr. *American Society for Metals, Thirteenth National Metal Congress and Exposition, Philadelphia, October 23–29, 1948, Properties of Metals in Materials Engineering*, 1949, pp. 100–123, illus. 13 references.

Effect of Valve Overlap and Compression Ratio on Variation of Measured Performance with Exhaust Pressure of Aircraft Cylinder and on Computed Performance of Compound Power Plant. Carroll S. Eian. *U.S., N.A.C.A., Technical Note No. 2025*, February, 1950. 38 pp., illus. 7 references.

New Lab Tests Diagnose Piston Oil-Ring Plugging. L. J. Test and C. A. Hall. *SAE Journal*, Vol. 58, No. 2, February, 1950, pp. 28–33, illus. (Extended summary of a paper: Oil-Ring; A Missing Link in Laboratory Tests.)

ROCKET (4)

A Theoretical and Experimental Investigation of Rocket-Motor Sweat Cooling. Joesph Friedman. *American Rocket Society, Journal*, No. 79, December, 1949, pp. 147–154, illus. 3 references.

A theoretical and experimental analysis of the gas-phase transpiration-cooling process for the case where the coolant fluid has physical properties identical to those of the mainstream fluid. An equation, relating the temperature of the porous wall to the rate of coolant flow, agreed well with experimental results obtained using air as the sweat coolant.

Sprite Rocket; Details of the de Havilland Rocket Unit for Assisting Comet Take-Off. *Flight*, Vol. 57, No. 2145, February 2, 1950, pp. 157–161, illus.

Production (36)

Vickers-Supermarine Attacker. II—Fuselage-Frames, Nose and Rear-Bay Subassemblies, Fuselage Assembly. S. C. Poulsen. *Aircraft Production*, Vol. 12, No. 136, February, 1950, pp. 41–48, illus.

Stores Organization. I—A Review of the System Evolved by Hawker Aircraft, Ltd., for Control of Airframe Manufacture. Richard Twelvetrees. *Aircraft Production*, Vol. 12, No. 136, February, 1950, pp. 37–40, illus.

Photo-Electric Guard; Light-Curtain Protection for Press-Brake Operation. *Aircraft Production*, Vol. 12, No. 136, February, 1950, p. 63, illus.

Tool Rework Can Meet Production Requirements. William Schweizer. *Aero Digest*, Vol. 60, No. 2, February, 1950, pp. 60, 86.

Steel Castings; Structural and Production Advantages, Specification Requirements for Aircraft Purposes. *Aircraft Production*, Vol. 12, No. 136, February, 1950, pp. 64, 65, illus.

Permanent Mold, Die, and Investment Casting of Magnesium. *Magnesium*, February, 1950, pp. 8–11, illus.

Canadair Concentrates on Sabre (North American, F-86) Production. *Canadian Aviation*, Vol. 23, No. 2, February, 1950, pp. 18–20, 42, illus.

Resistance Heating for Hot Forming 75S-T6 Aluminum. A. L. Schoellerman. *Product Engineering*, Vol. 21, No. 2, February, 1950, pp. 85–87, illus.

Smooth Skin-Surfaces; Obtaining Laminar-Flow Surfaces up to 40 Per Cent Chord. F. J. W. Digby. *Aircraft Production*, Vol. 12, No. 136, February, 1950, pp. 56, 57, illus.

Tables for Determining Reduction of Energy and Intensity of X-Rays and Gamma-Rays at Various Scattering Angles in Small Thicknesses of Matter. G. Allen. *U.S., N.A.C.A., Technical Note No. 2026*, February, 1950. 45 pp., illus. 22 references.

Results of Shear Fatigue Tests of Joints with $^3/_{16}$-Inch-Diameter 24S-T31 Rivets in 0.064-Inch-Thick Alclad Sheet. Marshall Holt. *U.S., N.A.C.A., Technical Note No. 2012*, February, 1950. 45 pp., illus. 3 references.

Reference Literature (47)

YEARBOOKS

Aviation Week's Seventeenth Annual Inventory of Air Power. *Aviation Week*, Vol. 52, No. 9, February 27, 1950. 164 pp., illus., diagrs., figs.

A review of aeronautical activities in 1949 which includes statistical data and specifications of U.S. military aircraft and air defense programs, data on domestic manufacturing industries, personal and industrial flying, electrical and electronic equipment, the progress of research, helicopters and the air-transport industry, and a study of aircraft developments in foreign countries.

Rotating Wing Aircraft (34)

Practical Instrument Flying in the Helicopter. Joseph A. Cannon and Owen Q. Niehaus. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 268.* 17 pp., illus. Members, $0.35; nonmembers, $0.75.

At speeds from 40 m.p.h. to the maximum, it appears that standard flight instruments, facilities, and regulations can be applied to the helicopter, and its stability and controllability are adequate to prevent undue pilot fatigue. Speeds below 40 m.p.h. require special instrumentation to measure low air speeds, to indicate yaw at slow speeds, and to predict the trend of helicopter attitude. An omnidirectional radio device is needed for homing, and a glide-path radio device oriented according to wind direction and velocity is required to enable the control-tower operator to indicate the proper approach angle and let-down.

Operation Whirlwind—Past, Present, Future. C. M. Belinn. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 187–198, Discussion, pp. 198, 199.

A report on the history and operating experience of Air Mail Route AM-84, established in 1947 by Los Angeles Airways, Inc. It reviews the problems of airway patterns, personnel, regulations, communications, business volume, equipment, and the provision of landing sites. The future of rotating-wing aircraft is projected by examining specifications, maintenance and operational techniques, legal and regulatory problems, and financial and economic aspects of the large transport helicopter. Airmail traffic increased by more than 610 per cent in 17 months. Structural modifications made in the company's shops increased the cubic capacity of one helicopter by 46 per cent and made possible an average daily utilization of 7.5 hours.

Research on Helicopters at the R.A.E., with Special Reference to the Stability of the Multirotor Helicopters. H. B. Squire. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 166–184, Discussion, pp. 184–186, illus. 14 references.

Evaluation of the stability characteristics of multirotor helicopters requires an understanding of the forces acting on a single rotor and of the field of flow near it. Measurements of those quantities for a 12-ft. diameter rotor in the 24-ft. wind tunnel of the Royal Aircraft Establishment agreed well with theoretical calculations for the force measurements up to the stall on the retreating blade. The comparison, however, was less satisfactory for the flow. Unlike the single-rotor helicopter, longitudinal stability of a tandem-rotor helicopter in forward flight depends on the c.g. position. To obtain longitudinal stability, it is necessary to move the c.g. ahead of the position for best performance. This is illustrated by the calculation of the stability of a typical tandem-rotor helicopter for two c.g. positions. It may be possible to provide longitudinal stability only above a certain speed that might be chosen to be the maximum rate of climb.

An Explanation of Some Important Stability Parameters that Influence Helicopter Flying Qualities. Alfred Gessow and Kenneth B. Amer. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 269.* 37 pp., illus. 5 references. Members, $0.35; nonmembers, $0.75.

An explanation in terms of fundamental physical quantities of the stability and control parameters of helicopters. Rotor control and the source of rotor damping both determine control sensitivity. Static stability with speed and static stability with angle of attack must be considered together in order correctly to evaluate the flying qualities of the helicopter.

Convertible-Aircraft Congress (Philadelphia, December 9, 1949). Alexander Klemin. *Aero Digest*, Vol. 60, No. 2, February, 1950, pp. 20, 21, 106, 107, illus.

Static Longitudinal Stability and Control of a Convertible-Type Airplane as Affected by Articulated- and Rigid-Propeller Operation. Roy H. Lange and Huel C. McLemore. *U.S., N.A.C.A., Technical Note No. 2014*, February, 1950. 49 pp., illus. 3 references.

Canadian Helicopter (SG VI-DM) in Military Version. *Canadian Aviation*, Vol. 23, No. 2, February, 1950, pp. 28, 64, illus.

Homemade Copter (EXCEL-I-Copter Model 100). *Aviation Week*, Vol. 52, No. 8, February 20, 1950, p. 15, illus.

Two in One (Helidyne, Mfd. by Gyrodyne Co.). *The Aeroplane*, Vol. 78, No. 2014, January 13, 1950, p. 46, illus.

Test Flight of the "Helidyne" (Gyrodyne Co. of America). *Aero Digest*, Vol. 60, No. 2, February, 1950, p. 64, illus.

Story of the Heliofly. Paul Baumgartl. *American Helicopter*, Vol. 17, No. 2, January, 1950, pp. 13–15, 22, illus.

Glide Path for Helicopter Let-Down. *American Aviation*, Vol. 13, No. 18. February 15, 1950, p. 17. illus.

Sciences, General (33)

MATHEMATICS

An Introduction to Relaxation Methods; Approximate Methods of Numerical Computation. F. S. Shaw. *Australia, Department of Supply and Development, Division of Aeronautics, Report No. SM. 78*, September, 1946. 82 pp., illus. 41 references.

Experimental Designs Balanced for the Estimation of Residual Effects of Treatments. E. J. Williams. *Australian Journal of Research, Series A, Physical Sciences*, Vol. 2, No. 2, June, 1949, pp. 149–168. 4 references.

Readers' Forum: A Note on the Evaluation of a Definite Integral. Henry E. Fettis. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, pp. 184, 185. 5 references.

MECHANICS—VIBRATION

Mechanical and Electrical Analogues for Vibration Isolation Problems. Walter W. Soroka. *Product Engineering*, Vol. 21, No. 2, February, 1950, pp. 104–108, illus.

Space Travel

Aero Medical Problems of Space Travel. Harry Armstrong, Heinz Haber, and Hubertus Strughold. *Journal of Aviation Medicine*, Vol. 20, No. 6, December, 1949, pp. 383–417, illus., figs.

If the mechanical and physical problems of energy supply and navigation that now hinder space travel could be solved there would still be physiological and psychological problems arising from the conditions encountered during the journey and upon arrival at destination. Man could probably withstand the effects of leaving the earth's field of gravitation and living in cramped quarters in the space craft, and could also tolerate solar and cosmic radiation, but present knowledge of atmospheres, temperatures, gravitational influences, and surface conditions on the nearby planets and the moon indicates that Mars would be the only celestial body that man could visit, and there auxiliary oxygen would be essential.

The Problem of Health Hazards from Cosmic Radiation in Flight at Extreme Altitudes and in Free Space. Herman J. Schaefer. *Contact*, Vol. 7, No. 2, July, 1949, pp. 14–20, illus. 6 references.

The Calculation of Take-Off Mass. A. V. Cleaver. *British Interplanetary Society, Journal*, Vol. 9, No. 1, January, 1950, pp. 5–13, illus. 7 references.

Calculations of the overall pay load mass ratio of a rocket based on the effective mass ratio that is required for a given characteristic velocity, for various values of the effective exhaust velocity, using the step principle and assuming a constant value for an arbitrary structural factor. A round-trip voyage from the earth to the moon is worked out for a chemical and an atomic rocket.

Psychological Problems of Space-Flight. E. T. O. Slater. *British Interplanetary Society, Journal*, Vol. 9, No. 1, January, 1950, pp. 14–18.

Application of psychological findings from wartime studies of men under battle stress to the situation in the cabin of a space ship.

Lunar Spacesuit. H. E. Ross. *British Interplanetary Society, Journal*, Vol. 9, No. 1, January, 1950, pp. 23–37, illus.

The Balancing Mechanism of the Inner Ear. A. E. Slater. *British Interplanetary Society, Journal*, Vol. 9, No. 1, January, 1950, pp. 18–23. 6 references. Its functioning in the absence of the sensation of weight or gravity.

Structures (7)

American Structural Design Trends. G. G. Green. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 404–415, Discussion, pp. 415, 416, illus. 4 references.

High-strength aluminum alloy is maintaining its position as the major aircraft structural material and is invading fields formerly dominated by steel. The only important limitation to its supremacy is the high temperatures encountered in supersonic flight. The use of 75S-T becomes doubtful at temperatures above 200° or 250°F., and the stainless steels and Inconel X are preferred at 300°F. and higher. Titanium shows great promise for the higher temperature ranges. Magnesium alloy is finding wider uses where high temperatures are not involved. The replacement of fabric coverings for movable control surfaces has broadened the uses of integrally stiffened metal sheet. Wing structural arrangements are affected by the need for torsional stiffness sufficient to avoid aileron reversal and by the intensity of beam loading. Thick wings for moderate-speed aircraft are influenced only slightly by the stiffness criteria, but stiffness is of increasing importance for thinner wings and higher speeds. Present trends indicate that stiffness criteria will supplant strength criteria and become the major structural consideration.

The Life of Aircraft Structures. H. A. Wills. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings*, pp. 361–389, Discussion, pp. 389–403, illus. 18 references.

The steady increase in working stresses in wings because of design refinement and reduction in load factor; higher cruising speeds and corresponding increase in number and severity of gust loads; increased aircraft size with reduction of resonant frequency of the wing structure to a rate approaching the gust frequency; and the development of new materials of high ultimate strength but without proportionally high endurance limits are design trends that increase the probability of fatigue failure of aircraft structures. The steady maneuvering and gust loads used in design and the factors affecting them are compared with the fluctuating loads arising from gust sequences on the resilient structure, by means of V-*g* recorder data. The fatigue resistance of the complete structure as measured in laboratory experiments, was considerably less than that of the joints, particularly in the region of 10^3 to 10^4 cycles to failure. Methods are suggested for obtaining load-endurance data and for estimating the time in flying hours before failure.

An Initial Approach to the Overall Structural Problems of Swept Wings Under Static Loads. E. E. Sechler, M. L. Williams, and Y. C. Fung. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 257.* 11 pp., illus. 6 references. Members, $0.35; nonmembers, $0.75.

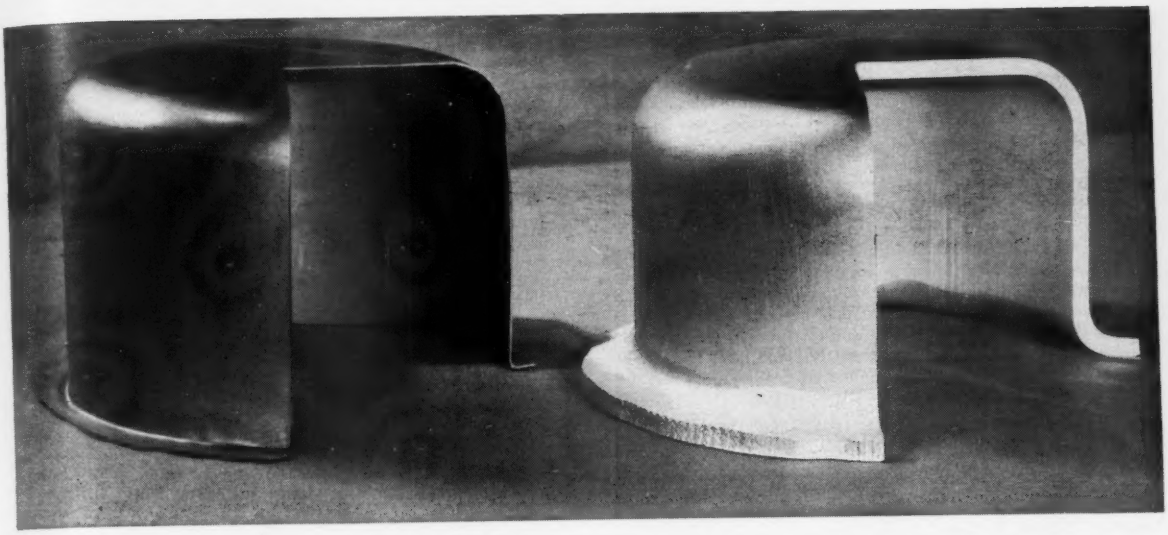
A general survey of the stresses in thin, swept wings of high solidity by theoretical, experimental, and electrical analog methods. The problem was reduced to a form amenable to theoretical analysis by assuming that the wing is replaced by an idealized section consisting of a thin cantilever plate of uniform thickness. A solution was obtained by expanding the deflection function in terms of a linear combination of the normal modes of vibrating bars. The coefficients were determined by the Rayleigh-Ritz method. The effect of sweep was taken into account by introducing oblique coordinates. The electrical analog method was used in solutions for a simply supported rectangular plate, a rectangular plate clamped on all edges, a cantiliver rectangular plate, and a swept cantilever rectangular plate. Typical experimental data are presented for stresses and deflections of the main specimen tested, a 24S-T aluminum plate of 10-in. chord, 1-in. thickness, and 50-in. span.

Types of Inelasticity of Structural Materials and Procedures of Design. Alfred M. Freudenthal. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 258.* 18 pp. Members, $0.50; nonmembers, $0.75.

A systematic survey of types of inelasticity and their relation to design procedures which covers conditions of high-temperature service and fatigue at normal and elevated temperatures, as well as the relation between design characteristics, real structural performance, and conventional mechanical results.

A System for the Excitation of Pure Natural Modes of Complex Structure. Robert C. Lewis and Donald L. Wrisley. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 253.* 25 pp., illus. 7 references. Members, $0.65; nonmembers, $1.00.

Complete experimental equipment for the shake testing of airplane structures, with the theoretical background and operating methods evolved, was based on the idea that, if numerous shakers were distributed over a complex structure, the adjustment of individual shaker forces at any natural mode frequency could be so arranged that only the natural mode in question would be excited. If such an excitation could be obtained, orthogonal to the one mode, all points on the complex structure would go through their maximum excursions at the same instant. Under such conditions there would be no forcing of adjacent modes and hence no phase shifts, the amplitudes of various points in the structure would clearly define the mode shape, and smooth decays could be obtained when the mode excitation was removed. The method allows positive separation and adequate definition of all the



ONE TOOL-ONE DRAW

Thin or Thick Material

THE GLENN L. MARTIN COMPANY

Baltimore, Maryland

and

HYDROPRESS, INC.

New York, N. Y.

announce

MARFORM

THE NEW DEEP DRAWING AND PRECISION METAL FORMING PROCESS

permitting

Deeper Draws • Reduced Tool Costs • Economical Production, Regardless of Quantities

FOR DETAILED INFORMATION WRITE TO:

HYDROPRESS · INC.

ENGINEERS *CONTRACTORS*

HYDRAULIC PRESSES · ROLLING MILLS · PUMPS
ACCUMULATORS · DIE CASTING MACHINES

570 LEXINGTON AVENUE · NEW YORK 22 · N. Y.

CHICAGO DETROIT SAN FRANCISCO SEATTLE WASHINGTON, D. C.

natural modes of a complex structure within a prescribed frequency range. The multiple shaker system may be adjusted to excite pure natural modes in accordance with a simple procedure utilizing an automatic normalizer and signals readily interpreted as to phase, frequency, and amplitude on a cathode-ray oscilloscope.

Relaxation Methods Applied to Two Problems of Two-Dimensional Stress Distribution Involving Mixed Boundary Conditions. W. H. Wittrick and W. Howard. *Australian Journal of Scientific Research, Series A, Physical Sciences*, Vol. 1, No. 2, June, 1948, pp. 135–160, illus. 3 references.

Relaxation methods have been used to determine the stress distributions in both a rectangular and a highly tapered plate under tension when the load is applied through absolutely rigid clamps. Both problems require the treatment of boundary conditions involving the values of both stresses and displacements. The solutions were obtained in terms of displacements, and the stresses were subsequently determined from them.

The Foundations of the Theory of Elasticity. F. D. Murnaghan. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 158–174. 2 references. American Mathematical Society, New York.

The Interpretation of Biaxial-Tension Experiments Involving Constant Stress Ratios. S. B. Batdorf. *U.S., N.A.C.A., Technical Note No. 2029*, February, 1950. 25 pp., illus. 20 references.

On Dynamic Structural Stability. G. F. Carrier. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, Proceedings*, Vol. 1, 1949, pp. 175–180. 5 references. American Mathematical Society, New York.

A General Solution for the Bending of Beams on an Elastic Foundation of Arbitrary Continuity. M. Hetenyi. *Journal of Applied Physics*, Vol. 21, No. 1, January, 1950, pp. 55–58, illus. 7 references.

Column Behavior in the Plastic Stress Range. John E. Duberg and Thomas W. Wilder, III. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 272.* 30 pp., illus. 3 references. Members, $0.35; nonmembers, $0.75.

If the behavior of a perfectly straight column is regarded as the limiting behavior of a bent column as its initial out-of-straightness vanishes, then the tangent-modulus load is the critical load—that is, the load at which bending starts. Load-lateral deflection curves for idealized H-section columns of various lengths and of various materials that have a systematic variation of their stress-strain curves, show that for columns whose material stress-strain curves depart gradually from the initial elastic slope, which is characteristic of stainless steel, the maximum column loads may be significantly above the tangent-modulus buckling load. If the departure from the elastic curve is abrupt, as in the case of high-strength aluminum or magnesium alloys, the maximum load is only slightly above the tangent-modulus load.

Inelastic Column Buckling. Tung-Hua Lin. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, pp. 159–172, illus. 9 references.

Effect of Centrifugal Force on the Elastic Curve of a Vibrating Cantilever Beam. Scott H. Simpkinson, Laurel J. Eatherton, and Morton B. Millenson. *U.S., N.A.C.A., Report No. 914*, 1948. 7 pp., illus. 5 references. U.S. Govt. Printing Office, Washington. $0.15.

Analysis of the Elastic and Plastic Stability of Sandwich Plates by the Method of Split Rigidities. P. P. Bijlaard. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 259.* 26 pp., illus. 23 references. Members, $0.65; nonmembers, $1.00.

A detailed but simple derivation of the author's formula for the critical thrust for antisymmetrical buckling of sandwich plates. The formula is based on the joint critical thrust of the single faces on the thrust, without taking account of the shear deformation of the core, and on the thrust if only that core shear deformation is taken into account. In computing the critical thrust values with and without the shear deformations of the core, the flexural rigidity of the faces is not taken into account. The method is applied to 12 different cases of loading and boundary conditions, for which the reduction coefficients for buckling in the plastic domain also are calculated and presented in graphs.

Buckling of Thin-Walled Cylinder Under Axial Compression and Internal Pressure. Hsu Lo, Harold Crate, and Edward B. Schwartz. *U.S., N.A.C.A., Technical Note No. 2021*, January, 1950. 29 pp., illus. 8 references.

A Small-Deflection Theory for Curved Sandwich Plates. Manuel Stein and J. Mayers. *U.S., N.A.C.A., Technical Note No. 2017*, February, 1950. 20 pp., illus. 7 references.

Reinforcement of Openings in the Stressed Skin of Airplanes. *U.S., National Bureau of Standards, Technical Report No. 1406*, January, 1950. 9 pp., illus. 5 references.

The plane stress theory can be used in the elastic region for computations of the median surface stresses in sheet with a hole and doubler-plate reinforcement, if the reinforcement is fastened with at least two rows of rivets or bonded into a unit with the sheet. Median fiber strains in the unreinforced regions of moderately curved sheet can be determined with sufficient accuracy by the same theory used for flat plates. A cutout in a square panel, particularly under shearing load, may reduce the shearing stress considerably. Reinforcement of the hole may increase the compressive and shear buckling stresses to values higher than those for a panel without a hole. The plane stress theory also may be used to compute accurately the stress distribution around a reinforced circular hole loaded by a pin, in a sandwich-construction plate.

The Edge Effect in Bending and Buckling with Large Deflections. K. O. Friedrichs. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 188–193. 8 references. American Mathematical Society, New York.

Large Deflection Theory for Rectangular Plates. Samuel Levy. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 197–210, illus. 11 references. American Mathematical Society, New York.

On Finite Deflections of Circular Plates. Eric Reissner. *American Mathematical Society, Symposium in Applied Mathematics, 1st, Brown University, August 2–4, 1947, Proceedings*, Vol. 1, 1949, pp. 213–219. 6 references. American Mathematical Society, New York.

The Solution of Aeroelastic Problems by Electronic Analogue Computation. Jonathan Winson. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 254.* 22 pp., illus. 6 references. Members, $0.50; nonmembers, $0.75.

Complex physical problems can be solved automatically by analog method machine computation. The basic aeroelastic equations for arbitrary wing motion are written in suitable form and entered in a commercial electronic computer. The elastic, inertia, and aerodynamic properties of the physical system are translated into fixed potentiometer settings of the computer, a small number of variable settings being reserved for aircraft forward velocity and initial flight conditions. The effects of the vortexes in the wake of the wing are represented by the output rates of simple electrical filters. In a study of flutter characteristics, for example, machine runs are made at several forward velocities, the wing being disturbed initially in each run, and pen traces of the resulting wing oscillations as functions of time yield the required aerodynamic data. The oscillations diverge above the flutter point. Examples with appropriate numerical comparisons illustrate the application of the method. Systems with many degrees of freedom and those having nonlinear components can be analyzed by machine with comparative ease.

Readers' Forum: Formulation of the Flutter Problem for Solution on an Electronic Analog Computer. Eugene F. Baird and Henry J. Kelley. *Journal of the Aeronautical Sciences*, Vol. 17, No. 3, March, 1950, pp. 189, 190, illus. 7 references.

First-Order Theory for Unsteady Motion of Thin Wings at Supersonic Speeds. Barry Moskowitz and W. E. Moeckel. *U.S., N.A.C.A., Technical Note No. 2034*, February, 1950. 26 pp., illus. 6 references.

Charts of Airplane Acceleration Ratio for Gusts of Arbitrary Shape. Bernard Mazelsky. *U.S., N.A.C.A., Technical Note No. 2036*, February, 1950. 15 pp., illus. 4 references

A Method of Determining the Effect of Airplane Stability on the Gust Load Factor. Bernard Mazelsky and Franklin W. Diederich. *U.S., N.A.C.A., Technical Note No. 2035*, February, 1950. 55 pp., illus. 5 references.

Oscillating Wings of Finite Aspect Ratio; Numerical Comparison of the Biot and Reissner Methods. P. Chiarulli. (Monograph No. 9.) *U.S., Air Force, Technical Report No. 102-AC49/-9-100,* December, 1949. 23 pp., illus. 12 references.

Some Considerations of the Flutter Problems of High-Speed Aircraft. E. G. Broadbent. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings,* pp. 556–576, Discussion, pp. 576–581, illus. 18 references.

Wind-tunnel studies of the effect of sweepback, and a detailed theoretical analysis of a hypothetical swept-wing airplane, show that the problems of coupled symmetrical flutter of the wing plans for high-speed aircraft are more serious and complex than those for conventional aircraft because of the effect of the aircraft body freedoms that can produce new forms of flutter involving a body-freedom mode and an elastic mode in place of two elastic modes. If the one elastic mode is primarily flexural, the flexural stiffness of the wing becomes an important factor in flutter prevention. A simple criterion for deciding whether a given normal mode is likely to yield a real critical flutter speed on combination with the body freedoms is based on the work of Minhinnick. In the case of the fundamental normal mode, the critical factor appears to be whether there is a change of incidence over the outer half of the wing.

Aeroelastic Problems at Supersonic Speed. A. H. Flax. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings,* pp. 322–359, Discussion, pp. 359, 360, illus. 34 references.

Difficulties involved in solving problems of the connection between aerodynamic and elastic effects at supersonic speeds can be traced to the differences between supersonic and subsonic flow and to the differences in configuration of aircraft and power plants designed for the two-speed ranges. Problems of supersonic flutter and static aeroelasticity of swept-back and straight wings are solved by modification of the conventional energy methods, and the results are applied to the influence of swept-wing and tail elasticity on static longitudinal stability and on lateral control effectiveness. Matrix iteration methods for determination of flexible swept-back wing loading are evaluated, and the influence of three-dimensional aerodynamic effects on wing bending divergence is determined approximately.

Readers' Forum: Station Functions in Flutter Analysis. J. H. Greidanus and A. I. van de Vooren. *Journal of the Aeronautical Sciences,* Vol. 17, No. 3, March, 1950, pp. 178, 179. 6 references.

The Gyroscopic Effect of a Rigid Rotating Propeller on Engine and Wing Vibration Modes. R. H. Scanlan and John C. Truman. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 255.* 18 pp., illus. 5 references. Members, $0.50; nonmembers, $0.75.

Assuming that the propeller itself is a rigid disc, an investigation was made of the vibratory gyroscopic effects resulting from the flexibility of engine mountings when the propeller is rotating. An engine mount may be regarded as a horizontal cantilever beam attached to the wing, and to have both horizontal and vertical flexibility. If the beam were infinitely rigid horizontally, then, under vibration, the gyroscopic moments induced in the propeller due to the resultant pitching motion of its axis would not induce propeller-axis yaw. However, engine-mount lateral stiffness, that allows propeller-axis yaw, may actually be less than vertical stiffness, so that gyroscopic effects will become effective as the propeller axis undergoes pitching vibrations at the tip of the cantilever engine mount. Gyroscopic effects, in flight, may modify theoretical calculations or ground-test results. This modification may be large if the propeller-engine pitching inertia or the propeller rotational inertia is large, if the effective radius to "pivot point" of the gyroscopic system is small, if the engine-mount lateral stiffness is low, or if more than one engine is running. The fact that the propeller is not actually rigid may be an alleviating factor of considerable importance.

Thermodynamics (18)

Readers' Forum: Heat Addition to a Flowing Gas. Roger Weatherston. *Journal of the Aeronautical Sciences* Vol. 17, No. 3, March, 1950, pp. 182, 183, illus. 6 references.

Water-Borne Aircraft (21)

The Relative Efficiencies of Large Landplanes and Flying Boats. D. Keith-Lucas. *International Aeronautical Conference (I.A.S. and R.Ae.S.), 2nd, New York, May 24–27, 1949, Proceedings,* pp. 598–643, Discussion, pp. 644–476, illus. 11 references.

The comparison of three dynamically similar landplanes with equivalent flying boats powered by the same engines, and having the same range and pay load shows that at weights greater than 100,000 lbs. the flying boat will be lighter and faster. At a gross weight somewhere between 250,000 and 500,000 lbs. either type will give the same speed, and for practical purposes the difference in performance between the flying boat and the landplane is extremely small at weights above 250,000 lbs. Availability of water bases and the distance to an alternate landing place in emergency are factors that overshadow flying efficiency regardless of the range or speed, or whether propeller or jet engines are used. Large aircraft are necessary to achieve material gains in traffic volume and bring increased efficiency in terms of pay load, but to provide landing facilities for such landplane units would be prohibitive in cost, giving the flying boat further economic advantages. The flying boat is safer over long water routes or in event of forced descent onto land, and it is not restricted to the limitations of landing gear. Its superiority in safety, economics, and reliability will continue to gain with increasing size.

Effect of Afterbody Length and Keel Angle of Minimum Depth of Step for Landing Stability and on Take-Off Stability of a Flying Boat. Roland E. Olson and Norman S. Land. *U.S., N.A.C.A., Report No. 923,* 1949. 13 pp., illus. 4 references. U.S. Govt. Printing Office, Washington. $0.15.

Water Landing Investigation of a Model Having a Heavy Beam Loading and a 30° Angle of Dead Rise. Sidney A. Batterson and A. Ethelds McArver. *U.S., N.A.C.A., Technical Note No. 2015,* February, 1950. 25 pp., illus. 4 references.

Theoretical Motions of Hydrofoil Systems. Frederick H. Imlay. *U.S., N.A.C.A., Report No. 918,* 1948. 25 pp., illus. 6 references. U.S. Govt. Printing Office, Washington. $0.20.

Preparation of Data for Computation of Vertical Flexural Modes of Hull Vibration by Digital Process. Alice W. Mathewson. *U.S., Navy, The David W. Taylor Model Basin, Report No. 632,* September, 1949. 12 pp., illus. 1 reference. (Revised Edition.)

Wind Tunnels (17)

An Internal Six-Component Balance for Model Testing at High Speeds. Henry H. Hoadley. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 270.* 16 pp., illus. Members, $0.35; nonmembers, $0.75.

A six-component strain-gage balance small enough to be mounted inside a sting-supported airplane model used in high subsonic or supersonic wind-tunnel tests. The design provides small interaction of forces and moments and makes possible the use of the wire type of strain gage. Since gages are interchangeable, replacements can be made in event of damage, or the range of forces can be altered by replacing the measuring units. Results obtained in two series of high Mach Number wind-tunnel programs proved the balance to be satisfactory.

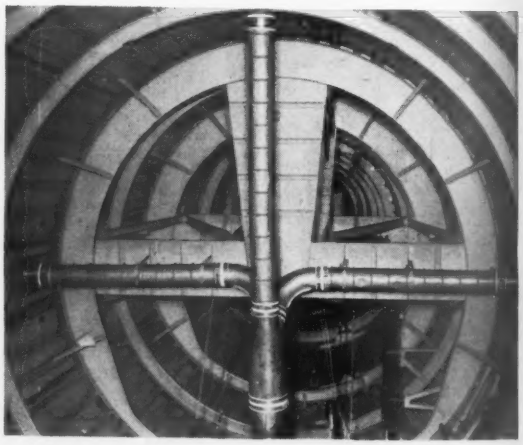
Effect of Tunnel Configuration and Testing Technique on Cascade Performance. John R. Erwin and James C. Emery. *U.S., N.A.C.A., Technical Note No. 2028,* February, 1950. 55 pp., illus. 10 references.

An Improved Schlieren Apparatus Employing Multiple Slit-Gratings. Tage A. Mortensen. *Review of Scientific Instruments,* Vol. 21, No. 1, January, 1950, pp. 3–6, illus. 1 reference.

The conventional knife-edge elements are replaced by multiple slit-gratings. The main advantage gained is the larger-sized working fields that can be achieved with an objective lens of given aperture. In some cases, greater intensity of image illumination is obtained, and usually the overall length of the system is reduced.

Here is real dependability for aircraft heating and ventilating ducts

REX-FLEX STAINLESS STEEL DUCTS



Light-weight, strong Rex-Flex Stainless Steel Flexible ducts offer the dependable solution for ducting which is subject to vibration, expansion and misalignment. Scientifically fabricated by advanced methods, they provide high resistance to fatigue without sacrifice of other required characteristics.

Rex-Flex Stainless Steel Ducting is made in sizes to 10″ I.D. Fittings are attached to make uni-metal assemblies without packing. There is a choice of convolution forms to suit the conditions of the applications. Write today for full technical details on safe, dependable Rex-Flex Ducting.

CMH—ONE dependable source
for every flexible metal hose requirement

• CMH manufactures all standard types of flexible metal hose, both convoluted and corrugated, in a variety of metals; expansion joints for piping systems; stainless steel and brass bellows; various conduits and special assemblies of these components.

CHICAGO METAL HOSE CORPORATION

CMH

Leaders in the Science of Flexonics
MAYWOOD, ILLINOIS
Plants at Maywood, Elgin and Rock Falls, Illinois
In Canada: Canadian Metal Hose Co., Ltd., Brampton, Ontario
FLEXON . . . . . identifies CMH products which have served industry for more than 47 years.

Aeronautical Reviews

Books

Fundamentals of Aircraft Structures

By Millard V. Barton. New York, Prentice-Hall, Inc., 1948. 298 pp., illus. $6.00.

If one is looking for a book that will introduce him to the stress analysis of monocoque aircraft structures in a simple and concise way, he will find such a book in Professor Barton's *Fundamentals of Aircraft Structures*. As pointed out by Professor Barton in the preface, because of the rapid development in aircraft engineering, the method and techniques in stress analysis are being improved and developed almost at the same rapid pace. Modifications in design are possible only through a broad understanding of all the related design functions and analysis, coupled with an appreciation for research development and production. In order to be able to do this, aeronautical engineers must have a solid foundation on the fundamental principles upon which the analysis of the structure is made along with an understanding of the physical concepts involved. Based upon this conjecture, Professor Barton has put a particular emphasis on the fundamental principles and left out most of the empirical methods.

This book contains 16 chapters that are grouped together into four parts. The first part, containing two chapters, treats aircraft loads and design specifications. The first chapter gives a simple and good discussion of design criteria, and the second chapter treats the aircraft loads. Part II is called by the author "Structure Analysis" and includes such subjects as behavior of loaded material, load transmission in single and multiple span beams and cantilever beams, frames and rings, and the various energy principles and methods.

Part III discusses the stability of slender structural elements such as column, thin plates, and stiffened panels. Included in this part is a treatment on beam columns.

Part IV gives the method of stress analysis of the various structural parts under various loadings such as bending, combined bending, and shear, torsion, combined torsion, bending and shear and includes a general discussion on allowable stresses and design considerations.

The reader will find this book to be an excellent, simple exposition of the stress analysis of monocoque aircraft. However, the analysis of truss type of airplane components has been left out. This book will serve as an excellent textbook for an introductory course or as a general introductory book for graduates in other fields who want to get into the field of stress analysis of monocoque structures. It is really amazing that the author has packed so much information into a book of this size. The writing is found to be clear and simple, and many numerical examples are included to acquaint the reader with application. Design methods based upon the empirical approach have been left out. This is because, as pointed out by the author, these techniques will be changed from time to time.

C. T. WANG
Associate Professor of
Aeronautical Engineering
New York University

An Introduction to the Gas Turbine

By D. G. Shepherd. New York, D. Van Nostrand Company, Inc., 1949. 387 pp., illus. $5.00.

This book, dedicated to Air Commodore Sir Frank Whittle, K.B.E., C.B., F.R.S., is presented "with the aim of filling a gap between the largely descriptive matter for the general reader and the technical reports and papers of interest only to the specialists."

The author, Assistant Professor at Sibley School of Mechanical Engineering, Cornell University, formerly with Power Jets Ltd. and A. V. Roe (Canada) Ltd., contributes to the field of gas turbines a great deal of personal experience. As may be judged by the chapters (Basic Dynamics, Flow of Gases, Gas Turbine Cycles, The Compressor, The Turbine, Combustion, Heat Exchangers, Some Existing Power Plants, Developments and Applications, Experimental Methods and Test Equipment, Auxiliary Equipment and Control Methods), the approach is largely thermodynamic in character. This seems proper in view of the importance of understanding the underlying fundamentals of component performance. Of interest also are three of the Appendices that cover Dimensional Analysis, Power Loss in Heat Exchangers, and Calculations of Counter-Flow Heat Exchangers.

The chapters on existing power plants and on development and applications, which refer to the aviation gas turbine as well as the other types, give a fair portrayal of the various activities in the field and is as up to date as may be expected in view of security regulations. By comparison, little attention is paid to mechanical problems, aircraft accessories and controls, and bearing and lubricating systems.

The value of this book lies particularly in the fact that the thermodynamic processes and characteristics of the various gas turbine components, such as the compressor, the combustor, and the turbine, are clearly and authoritatively treated. The attention paid to dimensional analysis and to experimental methods should endear the work of those who are themselves active in gas turbine development.

The British practice of using the centrigrade system throughout the book will prove only a minor drawback for American readers.

While Professor Shepherd's book and the recent book on *Gas Turbines for Aircraft* by F. W. Godsey and L. H. Young would appear to cover similar fields, it is interesting to note that there is practically no duplication on any of the subjects.

Professor Shepherd has succeeded admirably in covering the gas turbine field in such a manner that his book will be valuable to many students of the art. It is a welcome addition to the literature on gas turbines.

R. P. KROON
Manager of Engineering
Aviation Gas Turbine Division
Westinghouse Electric Corporation

Principles of Aircraft Propulsion Machinery

By Israel Katz. New York, Pitman Publishing Corporation, 1949. 477 pp., illus. $6.50.

Every so often a need arises for a new book chronicling the progress of the aircraft-engine industry during the years immediately preceding, together with an explanation of the major principles underlying that progress. A number of these books have been written in the past and have served their purpose excellently. However, the aircraft-engine industry is perhaps the fastest moving industry with regard to research

For information on I.A.S. Library Service Facilities, see page 49

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

90% of Jet Aircraft Manufacturers Choose REFRASIL

TO MEET ALL REQUIREMENTS OF SPEED OR SIZE

An amazing figure? Not when you realize that Refrasil, with a nominal thickness of only 3/16 inch is far more flexible and lighter in weight than standard high-temperature insulation materials. Yet Refrasil will withstand sustained temperatures up to 1800° F.; flash temperatures up to 2400° F., with absolutely no breakdown . . . or even discoloration.

Blankets, boots and covers, incased in stainless steel or other metal-foil material, can be preformed to your precise specification; to fit your every high-temperature aircraft insulation need.

Whatever your 'high-temp' insulation problem may be, our 'heat-wise' Engineering and Research staff can help you solve it with Refrasil. Call them in—any time or write the factory for insulation facts.

REFRASIL-PATENTED U. S. A.
Pat. No. 2-491-761
Pat. No. 2-500-092

BE "HEATWISE"...
THOMPSONIZE!

The H. I. THOMPSON CO.
Dept. A, 1733 Cordova Street
Los Angeles 7, Calif., U.S.A.

Eastern Rep.:
Fred W. Muhlenfeld
5762 Maplehill Road
Baltimore 14, Md.

In Seattle:
J. Lawrence Larsen
3608 Schubert Place
Seattle 22, Washington

and development. While in wartime the stress, as in all other industries, is on production of what has already been developed, in the long peacetime periods between wars the emphasis is on research and development of new and better power plants and their components. This creates, of course, a high rate of obsolescence of books of the type described. Since the war, need has again arisen for this type of book.

The reader should bear in mind that a work of this kind must cover the broader aspects of engineering progress in the industry. Such a work cannot, at the same time, be profound with regard to each component activity, or it would become a "5-ft. shelf" and require the contribution of many authors, each in his own field. This book is written for the purpose of compressing that hypothetical "5-ft. shelf" into one volume so as to give the reader an accurate picture of where we are today in aircraft powerplant and component development, and what engineers have been thinking about and contributing in the last 10 years. In meeting this objective, the book is a success.

The book has a respect for the value of long development and implies a just distinction between those engines and those components of engines into which years of development effort and millions of dollars have gone and those that are still relatively young or in the embryo stage. Virtually all types of aircraft power plants—the reciprocating engine, the turboprop and turbojet engines, the ram-jet, pulse-jet, and rocket engines—are discussed, and to this reviewer the book appears to be up to date, short of crossing security lines.

Each chapter of the book deals with one of the various larger departments of aircraft-engine development for performance or for structural soundness, and care seems to have been taken to present briefly lists of major requirements that engineers have found it necessary to meet in achieving successful design of products or components. The fundamental principles under which they are working to solve their problems in various fields are touched on, and curves or fundamental formulas are usually included in support of these.

Thus, the reader is looking through the engineer's eyes and benefiting from the consequent appreciation of detail, without which there would not be true understanding of the problems or of the achievements.

Few books that endeavor to introduce the engineering problems of an entire industry escape the drawback of having to deal with some subjects so briefly that they are not adequately explained. This book falls into that difficulty in the chapter on components, particularly with regard to compressors and turbines. Here, lists of requirements with regard to compressors and turbines. Here, lists of requirements of compressors and turbines, their physical description, and their good and bad characteristics relative to each other

should be, and sometimes are, presented in keeping with the other chapters of the book containing similar treatment of other fields. However, professors and engineers will find fault, it is believed, with the oversimplified explanation of aerodynamic-thermodynamic performance of these components, and the reader who is seeking an understanding of compressors and turbines as such should turn to other works that are more completely devoted to these subjects.

KENNETH CAMPBELL
Engineering Manager
Research Division
Wright Aeronautical Corporation

Book Notes

ELECTRONICS

Electronics in Engineering. W. Ryland Hill. New York, McGraw-Hill Book Company, Inc., 1949. 274 pp., illus. $3.50.

Based on a course in electronics for nonelectrical engineering students, this textbook is designed for the student of aeronautical, chemical, civil, or mechanical engineering and is concerned with instrumentation and control problems applicable to these fields. Vacuum and gas-filled tubes, rectification, amplification, feedback, and the cathode-ray oscilloscope are among the topics discussed. Circuits and wave forms are presented graphically, and problems from actual practice are solved in the text. A separate chapter deals with strain gages, transducers, the accelerometer, and recording elements. The author is an associate professor of electrical engineering at the University of Washington.

Frequency Modulated Radar. David G. C. Luck. New York, McGraw-Hill Book Company, Inc., 1949. 466 pp., illus. $4.00.

Following discussions on the principles of operation of frequency moduluated radar, radio apparatus used in FM radar systems, and apparatus for d ta conversion and utilization, a chapter is devoted to the motion of aircraft and missiles, including direct and level flight approach, vertical maneuvering, level flight rocket firing, effect of air resistance, rocket sighting, and motion in azimuth. The last two-thirds of the book deals with applications, including descriptions of single target FM radar systems such as the radar altimeter (AN/APN-1), low altitude automatic bombing equipment (AN-APG-4 and AN-APG-6), 1,500-mc. bombing equipment (AN-APG-17), rocket-firing equipment [AN/APG-17A (XN)], and speed measuring equipment [AN/SPN-2 (XN-1)] for carrier control of approach. Separate chapters deal with accessory circuits and methods of calibration, developmental single-target systems, and multiple-target systems. This volume was originally prepared a a final report to the Navy on contract work that began in 1941. The author is associated with RCA Laboratories Division of the Radio Corporation of America.

ENGINEERING PRACTICES

Three-Dimensional Engineering Drawing. W. E. Walters. Oxford, England, Pen-in-Hand Publishing Company, Ltd., 1949. 124 pp., illus. 10*s.* 6*d.*

A system for the drawing of pictorial views of complicated objects from blueprints, which previously was available only in the author's various articles in periodicals. Standard instruments are used, and a knowledge of orthographic projection is required of the reader. Following an introductory chapter, the conversion of lines, angles, and circular lines is taken up, leading into the concepts of rotation, tilt, and foreshortening. Straight-line solid geometry and its practical application are next discussed, followed by four chapters on curvilinear work. Rotation of three-dimensional views, intersection curves, and the layout of exploded views conclude the book. An appendix takes up in detail the construction analysis of the ellipse. Practical examples are worked out for all parts of the method.

EQUIPMENT

ELECTRICAL

The Electrical Engineer's Reference Book. E. Molloy, Editor. 4th Ed. London, George Newnes, Ltd., 1949. 1,880 pp., illus. 42*s.*

This handbook was first published in 1945 and has been revised annually. It consists of 32 sections written by 62 specialists, covering all branches of electrical engineering other than radio and telecommunications. Electricity in aircraft and automobiles is covered by a section of 22 pages, and among the other sections are included discussions of materials, transformers, cables and wires, transmission and distribution, switchgear and protective gear, electric motors, rectifiers and convertors, electrical measurements, welding, batteries, electronic engineering, automatic control, high-frequency heating, and electromagnetic equipment. A section of 192 pages on new developments, including those in aircraft equipment, sections on education and training, British laws and regulations, and a bibliography of about 1,500 books, articles, and specifications conclude the book. A subject index is included.

FUELS & LUBRICANTS

A.S.T.M. Standards on Petroleum Products and Lubricants. Philadelphia, American Society for Testing Materials, 1949. Pp. 687–1420, illus. $5.60, paper binding; $6.15, cloth binding.

The latest edition gives in their most recent form 120 A.S.T.M. standards and tentative standards, including 102 test methods and 12 specifications. Lists of definitions relating to petroleum and rheological properties are included. Motor and aviation fuels, Diesel and burner fuels, kerosene and illuminating oils, lubricating oils, greases, petrolatums and paraffin waxes, cutting fluids, electrical insulating oils, light hydrocarbons, hydrocarbon solvents, crude petroleum, and thermometers are among the materials covered. Methods of test for knock rating of engine fuels are issued in a separate manual and are not included in this compilation. The test methods presented include the A.S.T.M. standards widely used in this field as of November, 1949.

Data Book on Hydrocarbons; Application to Process Engineering. J. B. Maxwell. New York, D. Van Nostrand Company, Inc., 1950. 259 pp., illus. $5.00.

The first ten chapters are concerned with physical data, including the physical constants of hydrocarbons, miscellaneous organic compounds, and miscellaneous gases; average boiling point, characterization factor, and gravity of petroleum fractions; molecular weight of paraffins and petroleum fractions; vapor pressure; fugacity; critical properties; thermal properties; density; viscosity; and combustion. The final four chapters deal with flow of fluids, flow of heat, equilibrium flash vaporization, and fractionating towers, as used in the petroleum industry. Footnote references are included throughout. This volume grew out of various editions used by the Standard Oil Development Company, with whom the author is associated.

MANAGEMENT & FINANCE

Patent Practice and Management. Robert Calvert. Scarsdale, N.Y. P.O. Box 356, Scarsdale Press, 1950. 371 pp. $5.00.

The primary subjects of this book are how to obtain and use patents, how to administer the patent policy for the stimulation of research and invention, improvement of the morale of an organization, and how to serve best the interests of the patent sponsor. The management of patents is the primary point of view, and patent law is discussed mainly as it applies to this. Dr. Calvert, who is now a patent attorney, brings experience as an inventor, research director, and in various industrial concerns to the task of writing this excellent book.

MATERIALS

A Survey of General and Applied Rheology. G. W. Scott Blair. 2nd Ed. London, Sir Isaac Pitman & Sons, Ltd., 1949. 314 pp., illus. 40*s.*

This survey of known data on the deformation and flow of matter was first published in 1943. The present edition is considerably expanded to account for work accomplished during the war and for the greatly enlarged bibliography of the subject. The first part of the book deals with Rheological Phenomena and Their Measurement, including ideal materials, materials intermediate between liquids and solids, and variations in consistency produced by shearing and kindred phenomena. There are four chapters on rheological measurements. The second part is concerned with Rheological Interpretations and the Evidence of Psycho-Physical Investigations and discusses analytical and integrative methods, the power-law relation between stress, strain and time, and the evidence of psycho-physics. The bibliography contains about 1,400 items published up to the middle of 1947 and is preceded by brief summaries of about 350 papers on special aspects of rheology. The author index refers to the text, the summaries, and the bibliography.

MODEL AIRPLANES

Aeromodeller Annual, 1949. Compiled by D. J. Laidlaw-Dickinson and Edited by D. A. Russell. Leicester, England, The Model Aeronautical Press, Ltd., 1949. 192 pp., illus. 7*s.* 6*d.*

This second annual edition contains entirely new material, and the arrangement has been revised. This edition contains 32 more pages than that of 1948. Descriptions and plans of 35 model airplanes from 16 countries, including Russia, occupy the first 54 pages. The greater part of the book is devoted to 16 chapters on model construction and operation, contest results in 1949, records, and design data. Descriptions of 19 model engines, data on 20 new airfoil sections, two chapters on radio control, and a new chapter on gliders are included. Tables of data on the construction, design, and rigging of 34 control-line stunt models are another new feature.

NAVIGATION

Annual Reports of the Technical Committees for the 12-Month Period Ending 30 May 1949, Institute of Navigation. Washington, Institute of Navigation, August 16, 1949. 96 pp., illus.

The greater part of this volume consists of the report of the Committee on Standards for Air, covering America's Air Navigation Program, The Objective of Modern Air Navigation, A Procedure for Determination of the Optimum Range of an Airplane, and Tentative Standards, including standards on performance, personnel, equipment, and aeronautical charts. Performance standards include those on dead reckoning, pilotage, the general duties of the navigator, and on radio, celestial, pressure pattern, and Loran navigation. Reports are presented also of the Technical Advisor of the President of the Institute of Navigation, the Marine Committee, Technical Development Committee for Air, Committee on Tables and Devices for Navigational Computations, Committee for Upper Atmosphere and Interplanetary Navigation, and the Education Committee.

PHOTOGRAPHY

ABC's of Photogrammetry. Part I—Fundamentals. Gomer T. McNeil. **Part II—Tilt and**

F-80

T-33

F-90

World Leader in

JETS

The Lockheed Aircraft Corporation is the largest producer of jet aircraft in the world.

Lockheed's five-year continuous production of practical jet airplanes almost equals the total output of all other U.S. manufacturers combined.

The world's first mass producer of jets, Lockheed established this leadership with the F-80 *Shooting Star*, America's first operational jet airplane. This fighter, like other Lockheed jets (the T-33 two-place jet trainer and the new F-94 interceptor), is noted for its speed, versatility and strength.

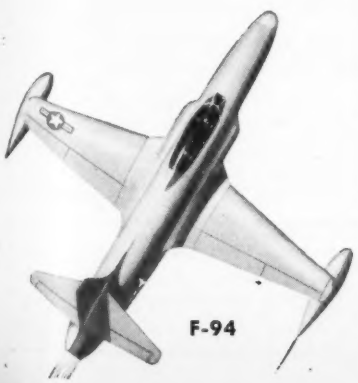
Carrying on this tradition is the newest member of the Lockheed jet family, the rugged, twin-engined F-90 Jet Penetration Fighter, now undergoing evaluation tests by the U.S. Air Force.

This broad experience in the development of practical jet aircraft is invaluable in the Lockheed laboratories where the designs of the future are taking shape today.

LOCKHEED

Aircraft Corporation, Burbank, California

Look to Lockheed for Leadership



Control Extension. Ralph O. Anderson. Washington, P. O. Box 1550, Photogrammetry; Ann Arbor, Mich., Edwards Bros., 1949. 124, 148 pp., illus. $3.00 per Vol., $6.00 per Set.

These volumes are designed to provide the beginning student with simple procedures for the solution of photogrammetric problems without the need for elaborate equipment, an understanding of the elementary graphics and mathematics required for the subject, an introduction to photogrammetric instrumentation through basic concepts, and an understanding of the broader aspects of problems, specifications, and requirements involved in photogrammetry. The emphasis in the second volume is placed upon determination of the tilt, swing, flying height, ground distances, and elevations of an aerial photograph, with most of the theory underlying basic principles omitted.

POWER PLANTS

JET & TURBINE

Rockets and Jets. R. Barnard Way and Nöel D. Green. Redhill, Surrey, England, Wells Gardner, Darton & Company, 1949. 176 pp., illus. 5*s*.

The authors' purpose is to acquaint the layman with the principles and some of the developments, past and future, of reaction propulsion. The first 72 pages are devoted to rockets and rocket motors, fuels, history, and a practical discussion of the interplanetary rocket. Following a chapter on duct motors, the next 81 pages deal with applications of the gas turbine to aircraft propulsion, and a final chapter takes up the future, with particular reference to the problem of economical fuels. This is a useful practical summary of the subject.

PRODUCTION

Jigs and Fixtures for Mass Production. Leland A. Bryant and Thomas A. Dickinson. New York, Pitman Publishing Corporation, 1947. 222 pp., illus. $3.75.

The authors' purpose is to present the essential information on jigs and fixtures for both the beginner and the expert, covering their design and construction, the various types, and tooling procedures. Assembly tooling is given particular attention, and the relations of plastics, pneumatics, and hydraulics to tooling are discussed in separate chapters, as is the Master Tooling Dock, designed as a positioner for the locating elements of assembly jigs or fixtures. A glossary of about 225 terms, a list of suggested tool symbols, and a tool production layout chart are included.

Handbook of Industrial Radiology. Institute of Physics, Industrial Radiology Group. Edited by J. A. Crowther. 2nd Ed. London, Edward Arnold & Co.; New York, Longmans, Green & Company, Inc., 1949. 218 pp., illus. $4.00.

Improvements in x-ray and photographic equipment and revisions reflecting other changes in modern practice in the last five years are accounted for in this new edition. A table of linear absorption coefficients has been added in an appendix. Contents: The Physical Principles of Industrial Radiology, W. J. Wiltshire. Requirements in Design of Industrial X-ray Equipment, E. J. Tunnicliffe. Quantitative Measurements in Industrial Radiology, R. H. Herz. The Response of Photographic Materials to X-rays, H. S. Tasker. The Radiography of Heavy Metals, R. Jackson. The Radiography of Light Metals, W. L. Harper. Gamma Radiography, C. Croxson. Some Uncommon Applications of Industrial Radiography, L. Mullins. X-Ray Protection, W. Binks.

Principles of Magnaflux. F. B. Doane and C. E. Betz. 3rd Ed. Chicago, Magnaflux Corporation, 1948. 388 pp., illus. $5.00.

This is the first extensive revision of this book since its original publication in 1940. This edition contains 100 more pages than the last, including new material on developments and applications during the war and postwar years. New discussions of field distribution and detectable defects, including factors affecting the detectability of discontinuities, are presented in separate chapters. The chapter on indications of surface and sub-

MARS
Lumograph
AMERICA'S ONLY IMPORTED DRAWING PENCIL
2886 J.S.STAEDTLER, INC MARS LUMOGRAPH
COSTS LESS BECAUSE IT LASTS LONGER!
Everything you want in a drawing pencil is in Mars Lumograph. It gives you the precise thickness and blackness of line you need for crisper, cleaner prints.
PROVE BY TRYING—
Accurately graded in 19 degrees from EXEXB to 9H — now packaged in metal boxes. If your dealer cannot supply you, write us.
Send coupon today for FREE sample.
J. S. STAEDTLER, INC
53-55 WORTH STREET
NEW YORK 13, N.Y.
SEND ME FREE—
Mars Lumograph Drawing Pencil
(____Degree)
J. S. STAEDTLER, INC.
53 Worth Street • New York 13, N.Y.
Name
Title
Firm
Address
City State
Dealer's Name AER

surface defects, giving examples of Magnaflux indications in various kinds of materials, has been reorganized and expanded. The chapters on inspection of welds, large castings, and forgings and on nonrelevant indications have been brought up to date, and extensive additions have been made to the discussions of interpretation of indications and evaluation of defects. About 40 illustrations have been added, and the bibliography has been revised, now listing 116 items.

SCIENCES, GENERAL

MATHEMATICS

Fourier Series. Werner Rogosinski. Translated by Harvey Cohen and F. Steinhardt. New York, Chelsea Publishing Company, 1950. 176 pp. $2.50.

This is a translation of Werner's *Fouriersche Reihen*, published in Berlin in 1930. An appendix on the notation used in the book has been added, including a discussion of concepts and results of the integral calculus required of the reader, and a bibliography of 11 books, including six published after 1935, is included. The discussion emphasizes the point of view of modern mathematics rather than the classical point of view.

Elements of Calculus. Therman S. Peterson. New York, Harper & Bros., 1950. 369 pp., illus. $3.50.

Designed as an introductory course in calculus, this text is intended to present the calculus both as a tool for use in applied fields and as an important branch of mathematical analysis. Integration and its application is introduced early in the book for the convenience of students interested in engineering and other applied fields. Reference formulas and curves of the more elementary mathematics are given in the introduction, and a table of integrals and five numerical tables are included at the end. The author is an associate professor of mathematics at the University of Oregon.

MECHANICS

Handbuch der Experimentalphysik. W. Wien and F. Harms, Editors. Vol. 3, Mechanik, Pt. 3, Technische Mechanik. Ludwig Föppl. (Leipzig, 1929.) Ann Arbor, Mich., J. W. Edwards 1948. 189 pp., illus. $5.75.

Following an introductory section on statics, the discussion takes up kinematics, including the rectilinear and curvilinear motion of a particle, harmonic vibrations, and plane, planetary, and elliptic harmonic motions of rigid bodies. A short section on the dynamics of a particle is followed by a discussion of the dynamics of systems of particles, including the balancing of multicylinder reciprocating engines, the torsional vibration of shafts, and the Coriolus force. The book concludes with sections on the dynamics of rigid bodies, impact, and friction.

An Introduction to the Theory of Mechanics. K. E. Bullen. Sydney, Australia, Science Press, 1949. 368 pp., illus.

This textbook was developed by the author in teaching a first course in applied mathematics. Prior knowledge of mechanics is not required of the reader, but concurrent study of the calculus is desirable. While a satisfactory rigor is maintained, the inductive aspects of the subject are given equal attention, and important features of scientific method are brought out. Vector methods are brought into use freely after the main concepts of dynamics have been explored for the restricted case of motion in a straight line. The presentations of two-dimensional statics and hydrostatics can be read independently if desired. A number of worked examples and problems are given, with answers. The author has taught at the Universities of Melbourne and New Zealand and is now a professor of applied mathematics at the University of Sydney.

PHYSICS

Basic Theories of Physics: Mechanics and Electrodynamics. Peter Gabriel Bergmann. New York, Prentice-Hall Inc., 1949. 280 pp., illus. $5.00.

The theoretical foundations are presented of Newton's mechanics and Maxwell's electro-dynamics and are developed through to the special theory of relativity. Mathematical techniques are considered in the role of tools, but discussions are included on variational calculus, vector and tensor calculus, and Fourier analysis, where appropriate. Physical ideas are emphasized, and topics are selected for their bearing on modern physics. Rigid body dynamics, for example, is omitted, but considerable attention is given to the differences between mechanics and a field theory and their incompatibility in a unified theoretical structure. The author is an associate professor of physics at Syracuse University.

The Theory of Groups and Quantum Mechanics. Hermann Weyl. Translated from the 2nd (Revised) Edition by H. P. Robertson. New York, Dover Publications, Inc., 1949. 422 pp. $4.50.

This translation was originally published in London in 1931. The author's purpose is to present the representation of continuous groups in a form suitable to the requirements of quantum physics and to furnish a tool of analysis of value to both the mathematician and the physicist.

STRUCTURES

Engineering Structures. (Colston Papers, Vol. 2.) London, Butterworths Scientific Publications; New York Academic Press, Inc., 1949. 260 pp., illus. $4.00.

The papers in this volume were presented at the Symposium on Engineering Structures held in September, 1949, at the University of Bristol under the auspices of the Colston Research Society.

Contents: Current Trends in Structural Research, R. V. Southwell. Carrying Capacity of Simply Supported Mild Steel Beams, J. W. Roderick and I. H. Phillips. Performance of Laterally Loaded Channel Beams, G. Winter, W. Lansing, and R. B. McCalley. Experiments on the Flexure of Rectangular Box Girders of Thin Steel Plating, S. R. Sparkes, J. C. Chapman, and A. J. S. Pippard. Plastic Deformation of Rectangular Plates under Direct Loads, H. G. Hopkins. On a Strut in a Non-linear Medium and the Waves in a Tension Field Shear Web, A. G. Pugsley. Dynamic Criteria of Buckling, N. J. Hoff. Effect of Variable Repeated Loads in the Plastic Theory of Structures, M. R. Horne. The Shortening Effect; A Non-Linear Feature of Pure Torsion, M. S. G. Cullimore. Effective Stiffness of Stringers to Locally Applied Loads, H. L. Cox. Performance of Compression Plates as Parts of Structural Members, G. Winter. Investigations on Aluminum Alloy Riveted Joints under Static Loading, A. J. Francis. Effect of Shrinkage on the Deformation of Concrete under Sustained Loads, F. Vogt. Design of Structures on the Basis of Assumed Deformations, A. van der Neut. Review of the Testing of Structures, J. B. B. Owen.

Special I.A.S. Publications

Sherman M. Fairchild Publication Fund Papers

No.		Price
126	External Sound Levels of Aircraft—R. L. Field, T. M. Edwards, Pell Kangas, G. L. Pigman, Civil Aeronautics Administration. 52 pages; 23 illus. (Photo-offset.)	$1.00*
100	Blade Pitching Moments of a Two-Bladed Rotor—R. W. Allen, Consulting Engineer. 19 pages; 5 illus. (Ozalid.)	$1.00*
101	Introduction to Shock Wave Theory—J. G. Coffin, Kaiser Fleetwings, Inc. 106 pages; 33 work tables & charts. (July, 1947, p. 28.)† (Ozalid.)	$3.50*
102	Electrical Resistance Strain Gages Applied to Wind-Tunnel Balances—Elmer C. Lundquist, Department of Engineering, State University of Iowa. 15 pages; 7 illus. (Ozalid.)	$0.80*
104	Tensor Analysis of Aircraft Structural Vibration—Charles E. Mack, Jr., Research Engineer, Grumman Aircraft Engineering Corporation. 66 pages; 6 illus. (April, 1947, p. 28.)† (Ozalid.)	$2.50*
105	An Evaluation of the Importance of Fatigue Phenomena in Aircraft—C. R. Strang, L. R. Jackson, L. F. McBrearty, R. V. Rhode, and R. L. Schleicher (A Round-Table Discussion). 34 pages; no illus. (Mimeographed.)	$1.10*
106	Measurement of Ambient Air Temperature in Flight—W. Lavern Howland, Lockheed Aircraft Corporation. 13 pages; 5 illus. (Ozalid.)	$0.50*
164	Applications of the Theory of Free Molecule Flow to Aeronautics—Holt Ashley, Massachusetts Institute of Technology. 88-page booklet; 28 tables & figures. (Photo-offset.)	$1.50*
165	Theory and Practice of Sandwich Construction in Aircraft (A Symposium). 100-page booklet; 45 illustrations. (Photo-offset.)	$2.50*
166	An Analysis of the Fluid Flow in the Spray Root and Wake Regions of Flat Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology. 68-page booklet; 14 illustrations. (Photo-offset and Multilith.)	$1.60*
167	On the Pressure Distribution for a Wedge Penetrating a Fluid Surface—Experimental Towing Tank, Stevens Institute of Technology. 36-page booklet; 13 illustrations. (Photo-offset and Multilith.)	$1.00*
168	Wave Contours in the Wake of a 20° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology. 54-page booklet; 38 illustrations. (Photo-offset and Multilith.)	$1.60*
169	The Discontinuous Fluid Flow Past an Immersed Wedge—Experimental Towing Tank, Stevens Institute of Technology. 42-page booklet; 5 illustrations. (Multilith.)	$1.00*
170	Wave Contours in the Wake of a 10° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology. 52-page booklet; 39 illustrations. (Multilith.)	$1.60*
229	Wave Profile of a Vee-Planing Surface, Including Test Data on a 30° Deadrise Surface—Experimental Towing Tank, Stevens Institute of Technology. 54-page booklet; 31 illustrations. (Multilith.)	$1.60*

* A 25% discount on these prices is allowed to Institute members. † Indicates issue of Review in which summary of paper appears.

Latest I.A.S. Publications

SECOND INTERNATIONAL AERONAUTICAL CONFERENCE

Covering the entire proceedings of the I.A.S.-R.Ae.S. Joint Conference held in New York, May, 1949, this 740-page volume contains 23 full-length papers, together with the important discussions of each. Over 400 illus. Bound vol.

Price—$17.50 ($15 to I.A.S. Members)

1st CONVERTIBLE AIRCRAFT CONGRESS PROCEEDINGS

The entire proceedings of the Congress held in Philadelphia, December, 1949, are covered in this one handy volume. The ten full-length papers on convertible aircraft, plus illustrations and important discussions of each paper, are included.

Price—$5.00 ($3.00 to I.A.S. and A.H.S. Members)

1949 AERONAUTICAL ENGINEERING INDEX

Here is the indispensable reference guide to all important technical papers and books on the aeronautical sciences published last year. Containing over 5,000 references and abstracts, indexed according to subjects, the volume for 1949 also contains a complete Author's Index.

Price—$5.00 ($3.00 to I.A.S. Members)

Indexes for 1947 and 1948 may also be obtained. In combination with the 1949 volume, these are available at following rates:

1947, 1948, and 1949 (3 vols.)—$10.00
($7.00 to I.A.S. Members)
1948 and 1949 (2 vols.)—$7.50
($5.00 to I.A.S. Members)

Institute of the Aeronautical Sciences
2 East 64th Street
New York 21, New York

Please send, postage prepaid, the following publications (as checked):

- ☐ **Second International Aeronautical Conference**
- ☐ **1st Convertible Aircraft Congress Proceedings**
- ☐ **1949 Aeronautical Engineering Index**
  - ☐ **1948 Index** ☐ **1947 Index**

Name.....

Address.....

.....

I.A.S. Sections

(*Continued from page 13*)

to be as high as 3×10^6 B.t.u. per hour per sq.ft. To cope with this high heat flux, designers have been forced to extrapolate empirical laws of heat transfer to a cooling liquid and to seek other unconventional methods, such as surface boiling heat transfer.

Following an explanation of turbulent flow in a duct and methods of sweat-cooling and film-cooling, Dr. Tsien discussed the choice of trajectories for rockets and ram-jets. He introduced an analysis of a jet-powered vehicle as an example of a dynamic trajectory wherein the angle of attack of the body is programmed to to give maximum range.

Prepared comments were presented by Dr. Th. von Kármán, Dr. W. B. Klemperer, and Dr. Louis G. Dunn. The comments brought to light the following: (1) Additional engineers are required who are schooled in advanced molecular physics; (2) new designs and methods of testing cooling configurations are required to handle high rates of heat transfer; (3) numerous physiological problems require solution before everyday travel by a rocket-propelled vehicle will be realized; and (4) although problems for travel by rocket vehicles now appear immense, they will all eventually be solved.

▶ **Mobilization**—The regular meeting of the Section was held on Thursday, February 16, in the form of a banquet in honor of J. H. Kindelberger, I.A.S. President, who was speaker for the evening. The meeting was held in the I.A.S. Western Headquarters Building and was attended by approximately 450 members and guests.

Speaking on "Six Distinguishing Characteristics of a Good Industrial Mobilization Plan," Mr. Kindelberger, who is Chairman of the Board and Chief Executive Officer of North American Aviation, Inc., discussed top-level preparedness planning, facilities, and equipment. He also considered materials and man power and the contractual and financial aspects of the air preparedness problem.

The I.A.S. President set forth the distinguishing characteristics of a good industrial mobilization plan: (1) The plan must be based on a realistic appraisal of available resources, including the capacity of industry; (2) it must be flexible and broad rather than inflexible and detailed; (3) it must relate the peacetime production program to anticipated emergency requirements; (4) it must be national in character, coordinating the needs of all services and coordinating the needs of the military with all civilian needs; (5) little would be gained by planning for more than the first 36 months after M-Day, because too many things can happen to make longer-range plans useless; and (6) the plan must be regarded at all times as a tool rather than as an end in itself.

Philadelphia Section

Dale Hamilton, *Secretary*

At the February 1 meeting, Walter Setz, Project Specialist, Naval Air Development Center, discussed the influence of soaring on aviation progress. Captain Ralph S. Barnaby, U.S.N. (ret.), was Chairman.

▶ **Sailplane Contributions**—Mr. Setz traced the evolution of the sailplane, showing how many of the outstanding developments of aviation were first introduced by the soaring fraternity: high aspect ratio, V-tail, tandem landing gear, spoilers or dive brakes, and single-spar full-cantilever wing.

The first developments of the sailplane were in Germany after World War I, with the Polish, Czech, and English developments following closely. As the sailplane developed, the rules and regulations for soaring contests also changed. At first, distance and duration were the primary objects; then came duration and flights to a predetermined point, followed by duration, altitude, and flights to a predetermined point and return. Another outstanding contribution of the sailplane is in the field of meteorology. Sailplane pilots were the first to study the internal structure of cloud masses. Mr. Setz pointed out that modern sailplanes have higher design speeds than light planes and that the altitude record for them is considerably above that of the light planes.

Captain Barnaby showed three reels of movies on gliding. These included the first drop of a glider from the dirigible "Los Angeles."

San Diego Section

Leon R. Wosika, *Secretary*

The February 9 meeting in the San Diego I.A.S. Building drew a group of 125 people from the local aircraft facilities. Frank W. Fink, Chief Engineer, San Diego Division, Consolidated Vultee Aircraft Corporation, spoke on "Recent Developments in British Jet and Turboprop Commercial Aircraft." Mr. Fink had recently returned from a trip to Great Britain, during which he spent considerable time inspecting the latest turbojet and turboprop transports, such as the de Havilland Comet, Vickers Viscount, and many others. His talk, which was illustrated by slides, gave a graphic picture of the current British jet transport developments that have recently aroused considerable interest in this country.

▶ **New Officers**—The following officers were elected for 1950: Chairman, D. H. Bennett; Vice-Chairman, E. P. Rhodes; Treasurer, C. C. Love, Jr.; Corresponding Secretary, L. R. Wosika; and Recording Secretary, R. P. White.

Other appointments announced were: Area Councilor Representative, Ralph L. Bayless (for West Coast); National Council Representative, E. G. Stout; Building Management Committee Chairman, W. T. Immenschuh; Program and Meetings Committee Chairman, R. J. Volluz; Membership Committee Chairman, C. A. Cordner; Library Committee Chairman, E. S. Jenkins; Publicity Committee Chairman, H. H. Ferris; and Nominating Committee Chairman, Jack Mason.

Texas Section

David L. Mellen, *Secretary*

Two meetings were held during February. The first, held on February 3 in the American Legion Hall, Grand Prairie, Tex., was attended by 130 persons. Russell J. McCrea, Section Chairman, presided. The principal speaker was Ernest G. Stout, Assistant to the Chief Engineer, Consolidated Vultee Aircraft Corporation, San Diego Division. Mr. Stout's paper* was the same as the one that he gave at the I.A.S. Eighteenth Annual Meeting in New York in January. Reaction to the paper was most favorable.

▶ **Boundary Layer**—One hundred persons attended the February 24 meeting, presided over by W. Andrew Pitman, Vice-Chairman. This meeting took place in the Melrose Hotel, Dallas, Tex. Dr. Hugh L. Dryden, Director, N.A.C.A., spoke on "Frontier Problems in Fluid Mechanics."

Dr. Dryden discussed the advances that have been made in boundary-layer theory and the shortcomings of the present theory. He definitely emphasized that test information is much in advance of theory in this field. He also emphasized the complexity of obtaining good wind-tunnel results because of the "slip-flow region" and boundary-layer transition

* To be published in a forthcoming issue of the JOURNAL OF THE AERONAUTICAL SCIENCES.

ROHR

Testing—

to build

better!

faster!

cheaper!

First of its kind ever designed . . . the ROHR-built test stand for testing exhaust systems. Constructed to test the exhaust system of the B-36 Super Bomber, it simulates temperature, pressure, vibration and other conditions experienced at altitudes *above 40 thousand feet.*

This unique construction offers proof of continued testing by ROHR to build things better! faster! cheaper! When it's made of metal . . . and you want it built properly . . . quickly . . . and at the right price . . . come to ROHR.

ROHR AIRCRAFT CORPORATION

In Chula Vista, California 9 miles from San Diego

LORD

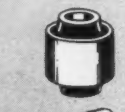
DYNAFOCALS

ENGINEERED IN DESIGN — IN MATERIALS

MR-40D2-5A SUB-ASSEMBLY
(Seven required per engine)
For BOEING 377
BOEING B-50
DOUGLAS C-124
MARTIN P4M1
MARTIN AM1
FAIRCHILD C119

Every factor involved in efficient engine suspension is carefully studied in designing every Lord Dynafocal. The flexible center-of-gravity suspension gives maximum engine vibration isolation and greater service life. Weight is saved through careful selection of materials and skilful design.

Write for a copy of Lord Service Bulletin containing valuable information on maintenance problems, suggestions for increased service life, and parts list. Mention engine or mounting in which you are interested.



COWL MOUNTS

INSTRUMENT PANELS, RADIO, NAVIGATION, COMMUNICATION EQUIPMENT

LORD MANUFACTURING CO
ERIE, PA.
Canadian Representative:
Railway & Power Engineering Corp. Ltd.

LORD
Vibration Control Systems

point. He presented an overall picture of speed and altitude boundaries. This lecture was illustrated by slides.

Toronto Section

H. C. Luttman, *Secretary*

An interesting meeting was held on March 2 in the New Mechanical Building of the University of Toronto. The speaker on this occasion was Dr. D. C. McPhale, Assistant Director of the Division of Mechanical Engineering, National Research Council of Canada

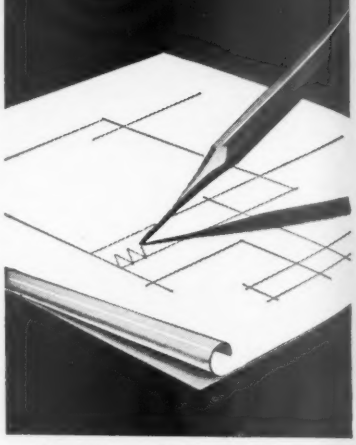
▸ **Flow Techniques**—Dr. McPhale's subject was "Modern Techniques in Aerodynamic Research." In a talk well illustrated with a number of slides, he presented a general outline of the methods that are now being used in the measurement of speed, pressures, temperatures, and other characteristics in subsonic and supersonic flow.

He emphasized that the measuring devices now in use were not always trustworthy and could be extremely misleading if employed without a full appreciation of their shortcomings. As an example, he showed how the conical pressure wave from the point of a rod-type static tube gave a completely false reading of the static pressure measured at the surface of the tube. He explained that the presence of these phenomena was disclosed by the use of optical methods, and he stressed the value of such methods in their examination and comprehension. However, even the optical methods were influenced by boundary-layer effects occurring on the walls of the tunnels and were therefore, in themselves, subject to suspicion. It was interesting to note that the interferometer was originally developed by Mach as long ago as 1880 and still has certain advantages in some conditions over the direct shadow and the schlieren methods.

In the measurement of temperature, Dr. McPhale explained the difficulties and the errors that could be introduced by temperature effects upon the leads of thermocouples. He gave a brief outline of methods being adopted to solve these problems

The lecture concluded with a few slides of a Mustang aircraft equipped to carry out tests on models using the high-speed field over the wing and thereby eliminating many of the shortcomings of the wind tunnel. Dr. McPhale also touched on such methods as the China clay technique for the investigation of boundary layer.

TRACING CLOTH for HARD PENCILS



● Imperial Pencil Tracing Cloth has the same superbly uniform cloth foundation and transparency as the world famous Imperial Tracing Cloth. But it is distinguished by its special dull drawing surface, on which hard pencils can be used, giving clean, sharp, opaque, non-smudging lines.

Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

Imperial Pencil Tracing Cloth is right for ink drawings as well.

IMPERIAL PENCIL TRACING CLOTH

SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE.

Student Branches

Academy of Aeronautics

On February 8 the official business meeting of the Branch was held and at its conclusion, the session was turned over to the fifth-term students competing for the I.A.S. Lecture Award. Two students were chosen from each term to act as judges. The student lecturers and their topics were: Lauriston Gale, "Know Your Supersonics"; Charles Fletcher, "Flying Saucer Data"; and John Pereira, "Future of Aviation."

Cal-Aero Technical Institute

Principal speaker at the February 14 meeting was Paul Mantz, racing pilot and stunt pilot for the motion-picture industry, who recounted his "Personal Observations and Experiences in Stunt Flying and Cross-Country Racing." Mr. Mantz is the only pilot to win the Bendix Race three times in succession.

Mr. Mantz told of his problems and preparations for some of his latest motion-picture stunt flights and stressed the fact that this type of work demands precision flying. In a discussion period, he told of the problems of preparing a plane for the cross-country Bendix Race and explained the navigational problems involved.

Other speakers were J. L. Dickinson, R. J. Kellner, and H. H. Nicholson, who gave their observations of a special cruise, aboard the aircraft carrier "Valley Forge," which had been arranged for I.A.S. members in the Los Angeles area. Cruise preparations, take-off and landing of jet- and propeller-type aircraft, catapults, and the ship's internal units were covered. Chairman Frank Seery presided.

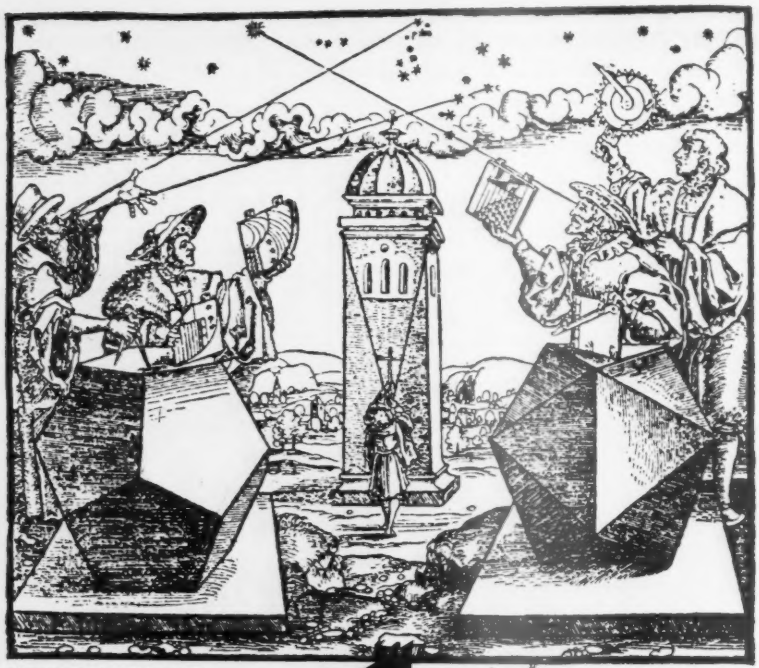
At the March 3 meeting, Student Branch members heard Lt. Hardy Glenn, U.S.N., describe the Naval Ordnance Test Station at Inyokern, Calif. Lieutenant Glenn spoke of the extensive housing and recreational facilities for the personnel connected with the operation of the base at Inyokern and of the many problems encountered in selecting the site and constructing the base. A film was shown which described some of the methods of firing ground-to-air and air-to-ground rockets and missiles. After an interesting account of rocket development and launching, Lieutenant Glenn told of the employment aspects at the Inyokern Test Station.

Just before closing the meeting, Mr. Seery, Branch Chairman, introduced the new officers elected on March 2: Chairman, John Sweeny; Vice-Chairman, A. E. Skenandore; and Secretary-Treasurer, Ray Rivero.

California State Polytechnic College

The first meeting of this Student Branch was held on December 13. William C. Heath presided, with 31 members and 19 guests attending. Officers were elected as follows: Chairman, William C. Heath; Vice-Chairman, Andrew Acampora; Recording Secretary, Richard L. Allen; Treasurer, Roy P. Bethel; and Corresponding Secretary, Charles A. Johnson. Honorary Chairman is Lester W. Gustafson. *Structures*, a film obtained from North American Aviation, Inc., was shown.

Forty-six persons attended the January 10 meeting. Two short papers were presented by members of the Student Branch: "The Cross-Wind Landing Gear," by Nordae L. Rhodes, and "A Comparison of Ram-Jet Helicopters with Conventional Helicopters." A C.A.A. film, *The ABC*



WOODCUT CIRCA 1530 *BETTMANN ARCHIVE*

Written in the stars

For centuries, man has looked to the universal constants, the stars, to establish his location on the earth's surface. The advent of modern, high-speed aircraft, however, raised a new problem in celestial navigation— that of plotting, instantly and accurately, the position of a rapidly moving object. Time-honored nautical methods proved inadequate.

The recently developed Kollsman Periscopic Sextant, with special automatic averager, enables the airborne navigator of high-speed craft to obtain a series of extremely accurate sights. It also eliminates the need for an astrodome.

The Periscopic Sextant reflects Kollsman leadership in the fields of precision instrumentation and fine optical systems. The same high standard of manufacturing and engineering skill marks the complete Kollsman line of Sard marine, sport, and opera binoculars. No finer prismatic binoculars are made.

KOLLSMAN AIRCRAFT INSTRUMENTS
PRODUCT OF
SQUARE D COMPANY
ELMHURST, NEW YORK GLENDALE, CALIFORNIA

of G, presented the problem of high acceleration and its physical effects on pilots.

On January 24, 45 persons viewed a motion picture produced by the R.A.F. entitled *Target for Tonight*, a portrayal of a complete bomber raid over Germany. Three senior Student Members presented papers: Glenn H. Morris, "The Wright Cyclone Engine, Compounded"; Arnold Manthey, "The Sperry Engine Analyzer"; and Don Lewis, "Turboprop Propeller Problems."

Two papers by seniors and two films were presented on February 14. Thirty-seven members and six guests took part in the meeting. Richard Fox spoke on "Freight Aircraft." H. J. W. Barnes' paper was entitled "Materials and Construction of Helicopter Blades." The first film, *Bell Telephone Review No. 2*, showed the use of the telephone in making calls from trains and remote islands. The other film, *Echoes in War and Peace*, showed the part played by Bell Telephone Laboratories in the development of radar and sonar.

Carnegie Institute of Technology

James E. Chikar, Chairman, presided at the February 21 meeting, which was attended by 14 persons. The main order of business was the election of new officers for the spring and fall semesters of 1950. Those chosen were: Chairman, Frank J. Stodolsky; Vice-Chairman, Carl F. Zorowski; Secretary, Herbert L. Bone, Jr.; and Treasurer, Edward B. Flora.

Catholic University of America

A meeting was held on February 15 in the Martin Maloney Chemistry Auditorium. Attended by 60 members, the session was presided over by Woodrow Seamone, Chairman. Willard Custer, President, National Aircraft Corporation, spoke on his channel-wing aircraft and showed black-and-white and colored motion pictures of it in flight.

Mr. Custer, in comparing his channel wing with the ordinary type of airfoil, explained how, in the channel-type wing, the propeller is so positioned that great masses of air are moved through the channel even when the aircraft has zero forward velocity, thus producing great lift. He stated that, with the channel wing, thrust is equal to lift at zero velocity and that he intends shortly to demonstrate that his aircraft can take off vertically from a standstill. Questions were answered after the talk by Mr. Custer and Mr. Cook, Professor of Aeronautics, whom Mr. Custer thanked for his

OPENINGS FOR DESIGN ENGINEERS

We have several immediate openings for design or development engineers. Mechanical and electrical engineers with considerable experience in design of instruments or control preferred. Excellent opportunities with leading manufacturer of automatic controls. Attractive salary. Location: Minneapolis. Contact J. Arthur Johnson, Employment Manager.

MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

2753 Fourth Avenue South, Minneapolis 8, Minnesota

ENGINEERS

Aerodynamic . . . Structure

There are a few excellent positions available for experienced engineers with enthusiasm, imagination, ingenuity, and scientific education.

AERODYNAMIC ENGINEERS: 2–5 years' experience

STRUCTURES ENGINEERS: 3–6 years' experience

Salary commensurate with ability

Many Employee Benefits

Submit resume outlining qualifications.
Personal interview will be arranged.

THE GLENN L. MARTIN COMPANY

BALTIMORE 3, MARYLAND

FUTURAIRE ENGINEERING

Specializing

in

Model Making **Devices**

Developing & Designing

Write for additional information

Parkville Sta. Box #8 Brooklyn, N. Y.

ENGINEERS

Expanding Engineering Department of Convair needs experienced

AERODYNAMICISTS
AIRCRAFT DESIGNERS
AIRCRAFT DRAFTSMEN
AIRCRAFT STRUCTURAL ENGINEERS

And specialists in all phases of aircraft engineering for work on the B-36 and other military projects. Please include summary of experience in reply.

Engineering Personnel Office

CONSOLIDATED VULTEE AIRCRAFT CORPORATION

Fort Worth, Texas

Now available

Gives theory a *practical* meaning

ELEMENTS OF PRACTICAL AERODYNAMICS

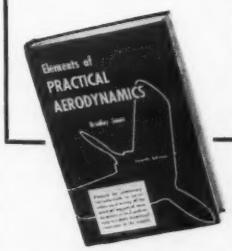
Fourth Edition

By BRADLEY JONES, *University of Cincinnati*

The material in this new edition has been completely rearranged to make for increased logic and continuity of the subject matter. A large number of new, more realistic illustrative problems have been added, together with step-by-step solutions. The author goes into greater detail on ideal fluid and vortex motion, circulation, boundary layer, speed of sound, Bernoulli's equation and stagnation pressure for compressible fluid, V-g diagrams, and longitudinal dynamic stability.

March 1950 444 pages $5.00

EXAMINE BOOK FOR 10 DAYS



ON APPROVAL COUPON
JOHN WILEY & SONS, INC.,
Dept. AER-5-50
440 Fourth Ave., New York 16, N. Y.

Please send me, on 10 days' approval, a copy of Jones' ELEMENTS OF PRACTICAL AERODYNAMICS. If I decide to keep the book, I will remit $5.00 plus postage; otherwise I will return the book postpaid.

Name.....
Address.....
City.....Zone....State.....
Employed by.....
(Offer not valid outside U. S.)

DEPENDABILITY ✓

YOU'VE GOT IT—WITH A "CAL-AERO TECH" GRADUATE

DESIGNERS AVAILABLE

Immediately useful, without break-in

EXPERIENCE

4000 hours on board and in aircraft shops, with fundamentals and actual work assignments under supervision of Aircraft Factory Experienced Designers—Specializing in design of component parts—proficient in layout, strength checking and manufacturing process analysis.

HIRE A "CAL-AERO" GRADUATE—HE'LL DELIVER THE GOODS

NEW CLASS GRADUATES EACH MONTH

Serving DOUGLAS • LOCKHEED • NORTH AMERICAN • BOEING NORTHROP • CURTISS-WRIGHT • CONVAIR • RYAN AIRESEARCH and MANY OTHERS

PHONE OR WRITE

CAL-AERO TECHNICAL INSTITUTE

GRAND CENTRAL AIR TERMINAL • GLENDALE 1, CALIF.

VELBESTOS VELBESTOS VELBEST

GASKETS

are important in an aircraft engine.
Our VELBESTOS 170-1 conforms to
A M S Specification 3232E.

May we send samples for experimental purposes?

THE VELLUMOID COMPANY

WORCESTER 6, MASS.

aid and encouragement in the development of the channel wing.

Clarkson College of Technology

At the January 11 meeting, attended by 35 members, the following new officers were elected: Chairman, Stephen A. Murtaugh; Vice-Chairman, Stuart G. Miller; Secretary, Alvin H. Jacobs; and Treasurer, S. Sanders Bagdan.

Two films were shown at the February 15 meeting, *New Wings for Peace* and *A Study of Air Flow by Means of Smoke*. The latter film dealt with the effect of shape on lift and drag, as shown by the evolution of the fuselage and wing surfaces from flat plates and pure cylindrical shapes. The effect of camber, flaps, and slots was effectively demonstrated. Forty persons were present.

Georgia Institute of Technology

A Boeing film on the B-36 and one on the Goodyear Trophy Race were shown to members on Friday, February 10. The Student Branch Secretary announced election of the following new officers: Chairman, Seymour Salmirs; Vice-Chairman, James H. Corbett; Secretary, Wesley M. Mann, Jr.; and Treasurer, Paul Baldasare.

Illinois Institute of Technology

The main event of the January 3 meeting was the election of officers for the coming semester. Those elected were: Chairman, Paul Margolis; Vice-Chairman, Jack Moeller; Secretary, Frank Halwax; and Treasurer, Robert Wildey. Marvin H. Zelibor was the presiding officer at this meeting.

Louisiana State University

Election of new officers took place on January 19. Twelve members attended, with outgoing Chairman John Monroe Palmer presiding. Those elected were: Chairman, Joseph Cornish; Vice-Chairman, Theodore Gordon; and Secretary-Treasurer, William Drake.

Oregon State College

Principal event of the January 25 meeting was the showing of a motion picture obtained from The Glenn L. Martin Company. Entitled *Wing Test*, it demonstrated a test to destruction of a wing of a Martin PBM-3. Exactness of the calculations and good organization of the test were evidenced by failure of the wing at the predicted design load. Elliott R. Buxton was chairman of the session, at which 24 members were present.

Parks College of Aeronautical Technology

Jack Durand, Instructor in Aeronautical Engineering, Parks College, was guest speaker on January 19. He spoke of his visit to the N.A.C.A. at the Langley Air Force Base last year. He discussed the emphasis being placed on high-speed research and the transonic and supersonic wind tunnels used in this research program. Mr. Durand also gave an account of a visit he had made to the David Taylor Model Basin. The meeting was attended by 42 members. Presiding officer was Chairman Wallace E. Carr.

Spartan College of Aeronautical Engineering

On January 10, with 48 members present, the following officers were elected: Earl G. Blosser, Chairman; Allyn M. Heinrich, Treasurer; and Merle F. Shelton, Corresponding Secretary. A film, *Unfinished Rainbows*, produced by the Aluminum Company of America, was shown at the January 24 meeting. It was viewed by 59 members and guests.

Stanford University

John A. Stern, Operational Engineer with United Air Lines, Inc., was speaker at the January 24 meeting. The Vice-Chairman of the Student Branch, Rex M. McConnelly, presided. In his talk on "Weight and Its Effect on Aircraft Performance," Mr. Stern used actual figures of several well-known airplanes to show how many factors enter into the determination of the many different types of load the aircraft can carry—fuel, cargo, passengers, luggage, crew, instruments, and others. He stressed the necessity for cooperation not only within the company but between the aircraft companies and organizations such as the C.A.A. and the A.O.P.A. He emphasized that an engineer must know and be able to use economics. He showed the effect of seemingly secondary items—temperature, humidity, and passenger idiosyncrasies—on air-line operations. Following Mr. Stern's talk, the ten members present elected John Traynor as Chairman for the following year.

News of Members

Commander James O. Biglow, M.I.A.S., has been transferred to the U.S. Naval Air Station at Corpus Christi, Tex., from Reaction Motors, Inc., Lake Denmark, N.J., where he was Bureau of Aeronautics Representative.

COORDINATOR

John J. Collins, Jr., M.I.A.S., is now Assistant Chief of Research for Coordination and Liaison, Lewis Flight Propulsion Laboratory, N.A.C.A., Cleveland. Previously, he was Chief, Engine Performance and Materials Division.

Robert M. Bram, T.M.I.A.S., formerly employed by Goodyear Aircraft Corporation, is now an Aeronautical Design Engineer in the Engineering Department of Chance Vought Aircraft Division, United Aircraft Corporation, Dallas, Tex.

Lloyd L. Clevenger, T.M.I.A.S., is now employed at the U.S. Naval Air Missile Test Center, Point Mugu, Calif., as a Grapher in the Special Analysis Branch of the Range Instrumentation Department, for the Northrop Aeronautical Institute.

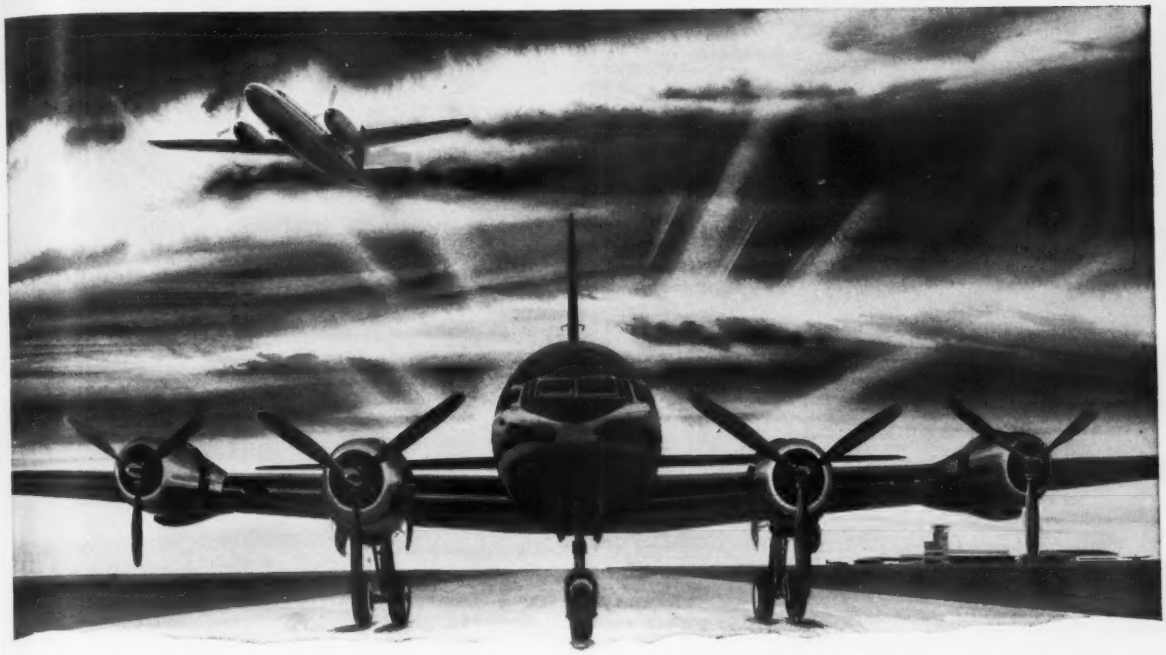
Corwin D. Denney, M.I.A.S., President, American Helicopter Company, has announced advanced flight tests for U.S.A.F. of "Top Sergeant" two-bladed pulse-jet helicopter. Pulse-jet engines, mounted at rotor blade tips, weigh less than 25 lbs. each and have a minimum of moving parts and accessories.

Donald L. Derrom, M.I.A.S., is employed by Kennedy-Van Saun Manufacturing and Engineering Company, New York, as Field Engineer in Beira, Mozambique, South East Africa.

Walter M. Fitch, A.M.I.A.S., has transferred from Service Engineering, Boeing Airplane Company, Wichita, to XB-47 Flight Test Inspection.

Donald W. Haarman, M.I.A.S., is an Engineer with Beautaire Sales Company (air conditioning), Hollis, N.Y.

Thaddeus A. Hawkes, T.M.I.A.S., is Engineer with Arma Corporation,



NOW...AND IN THE FUTURE

Curtiss Electric Propellers and Turbo-Props

Since the days when propellers were carved from wood by hand, Curtiss Propellers have paced aircraft propulsion progress.

The first all-metal propeller was a Curtiss product. Curtiss-Wright pioneered the electric propeller . . . and the first full-feathering propeller . . . perfected and proved the hollow steel blade . . . introduced automatic synchronization . . . developed the reversible propeller now in universal military and commercial use.

Today, Curtiss Electric Propellers are the standard of quality wherever aircraft fly. They equip the modern post-war transports of the world's leading airlines . . . and superbombers like the Air Force B-36. In over 40 different aircraft models now in operation, Curtiss Electric Propellers have built an international reputation for dependability, durability and flexibility of electrical control.

Against a background of demonstrated performance, Curtiss-Wright faces the dawning era of trans- and super-sonic speeds well prepared to anticipate and meet new trends in military and commercial aircraft . . . to maintain the leadership it has established.

In the same Curtiss-Wright laboratories where present production types were conceived in advance of their time, new propellers have taken shape. Propellers of the future, built by Curtiss-Wright, are being flight tested at speeds up to 600 miles per hour. Turbo-props under development today will be ready when they are needed tomorrow. Every avenue of research is continuously being explored.

Curtiss-Wright propellers will play a major role in the conversion of current experimental aircraft developments into accepted practice. Meanwhile, Curtiss-Wright will continue to produce the propeller types required to maintain America's superiority in the air . . . time-tested Curtiss Electric Propellers of advanced design whose every feature has been proved. *Propeller Division, Curtiss-Wright Corporation. Caldwell, New Jersey.*

These leading Airlines use Curtiss Electric Propellers

BOEING 377 STRATOCRUISER	American Overseas Airlines United Air Lines
CONVAIR 240	American Airlines Northeast Airlines Swissair
DOUGLAS DC-6	American Airlines BCPA (Australia) Philippine Airlines SAS (Scandinavia)
LOCKHEED CONSTELLATION	Air France Air-India International BOAC (Great Britain) KLM (Netherlands) LAV (Venezuela) QEA (Australia) South African Airways
AERO SUD EST SE 2010	Air France

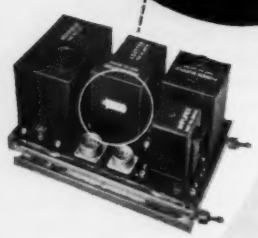
CURTISS WRIGHT

Functionally
PACKAGED
Electronics

the mecha
MINI·CHOPPER
PATENT PENDING

Servomechanisms, Inc.
Announces the
MINI·CHOPPER
A precision miniature
device for use in
Modulation . . .
Demodulation . . .
Rectification . . .
Inversion . . .
The ultimate in miniature
functional packaging
combining the maximum in
Performance . . .
Stability . . .
Dependability . . .

INFORMATION FOR SPECIFIC
APPLICATIONS ON REQUEST.



Designers and
Producers of
precision
electronic
devices for
military and
commercial
application.

SERVOmechanisms
INC.
Old Country & Glen Cove Roads
MINEOLA, N. Y.
Garden City 7-0754-5-6

Brooklyn, N.Y., manufacturers of electro-mechanical fire-control equipment.

Stanley Hiller, Jr., T.M.I.A.S., has announced that United Helicopters, Inc., of which he is President, will do business under name of Hiller Helicopters. Corporate title—United Helicopters, Inc.—will remain unchanged.

Mahidol Hongskul, M.I.A.S., has been advanced to Director, Directorate of Works, Royal Thai Air Force, Bangkok, Thailand.

Frank W. Hulse, M.I.A.S., has been re-elected President and a Director of Southern Airways, Inc.

David H. Kaplan, T.M.I.A.S., is Project Engineer with Doman Helicopters, Inc., Danbury, Conn. Previously he was Cockpit Designer, Piasecki Helicopter Corporation.

Joseph T. Lester, Jr., T.M.I.A.S., is employed as a Mechanical Engineer by the Self-Locking Carton Company.

H. G. Srinivasa Murthy, M.I.A.S., has been sent by the government of India to Zurich for about a year to take advanced technical training. Mr. Murthy, who was formerly Senior Designer, Hindustan Aircraft, Ltd., Bangalore, Mysore, India, may be reached in care of the Indian Legation, Berne, Switzerland.

G. Truxton Ringe, M.I.A.S., is employed in the Aviation Section, Transportation Sales Department, Westinghouse Electric Corporation, East Pittsburgh, Pa. Mr. Ringe comes to East Pittsburgh from the Westinghouse office in Los Angeles.

Edward J. Sullivan, T.M.I.A.S., transferred from the Seattle to the Wichita plant of Boeing Airplane Company, is Flight Test Analyst on the B-47 jet bomber.

Colonel Clarence M. Young, M.I.A.S., became a Vice-President of Pan American World Airways on March 1, following $2\frac{1}{2}$ years as General Manager of the Los Angeles Department of Airports. From 1934 to 1945, Colonel Young managed the Trans Pacific Division of Pan American.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Transferred to Associate Fellow Grade

Harmon, Sidney Morris, B. of Ae.E., Aero. Research Scientist G.S. 12, Lewis Flight Propulsion Lab., N.A.C.A.

Rosen, Dexter, B.S.E. in Ae.E., Field Test Dir., Bell Aircraft Corp.

Vogeley, Arthur W., S.B. in A.E., Aero. Research Scientist, Section Head, Special Projects Branch, Flight Research Div., N.A.C.A., Langley Air Force Base.

Elected to MEMBER Grade

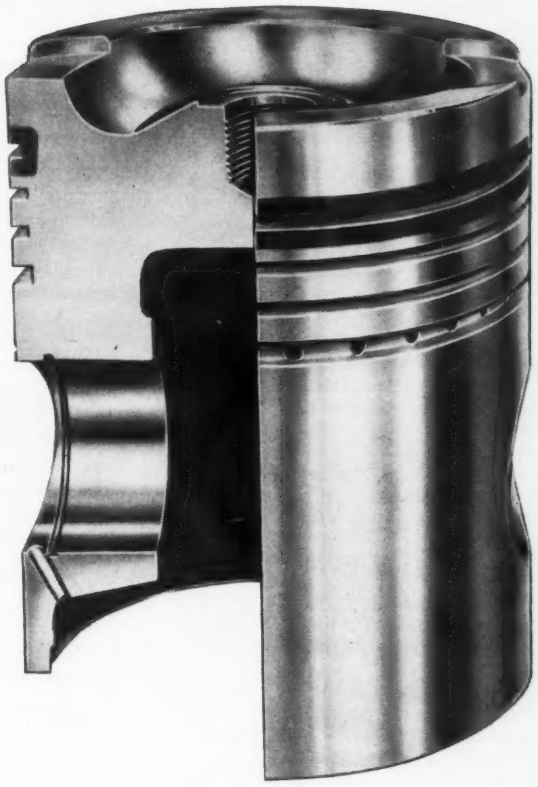
Anderson, Clarence B., M.S. in M.E., Assoc. in Mechanical Engineering Dept., Columbia University.

When you write to manufacturers
whose advertising appears
in the
Aeronautical Engineering Review,
it will be
of interest to the companies
and of benefit to the Institute if you
mention that you saw it
in the
Aeronautical Engineering Review

G&O
Radiators
35th Year
ENGINE COOLING RADIATORS
•
OIL COOLERS
The G&O Manufacturing Co.
NEW HAVEN, CONNECTICUT

One Secret of

INCREASED POWER
LOWER MAINTENANCE
LONGER ENGINE LIFE



A NI-RESIST INSERT . . .
bonded into aluminum alloy piston by the Al-Fin process.

ELIMINATE excessive failures from wear, burning and erosion in the ring area of aluminum alloy pistons . . .

Particularly in the top ring groove . . . which encounters the most heat, receives the least lubrication, and faces wear from abrasive dust and dirt coming in through the intake.

A NI-RESIST® band gives the stop-sign to excessive ring groove wear and, thus, curbs unnecessary oil consumption and needless loss of power due to "blow-by."

Records show that these troubles end when the Al-Fin process for molecular bonding of aluminum to iron or steel is used to make Ni-Resist ring carrier bands an integral part of pistons.

Ni-Resist . . . a high nickel alloy cast iron . . . meets all demands for this application. It resists heat, corrosion, metal-to-metal wear and galling. Moreover, its high thermal expansion coefficient is close to that of aluminum alloy 142 and 132 ("Lo-Ex") to which it is bonded by the Al-Fin process . . . developed by Al-Fin Division of Fairchild Engine and Airplane Corporation, Farmingdale, L. I.

Rings operating in Ni-Resist bands are unable to chew their way into the ring bands, and service records show remarkable improvement in piston life, as well as higher power per cylinder.

United Engine & Machine Company of San Leandro, California, is one of several concerns in this country and abroad, licensed to manufacture bimetal products by the Al-Fin process. United's "Dualoy" bonded aluminum Ni-Resist pistons are now marketed as original equipment and replacements for both gasoline and Diesel engines in trucks, buses and tractors.

We welcome the opportunity to give you counsel and data on the use of Ni-Resist for this and other uses in industry.

Standard aluminum alloy piston which failed in the top ring groove.

EMBLEM OF INCO SERVICE TRADE MARK

Over the years, International Nickel has accumulated a fund of useful information on the properties, treatment, fabrication and performance of engineering alloy steels, stainless steels, cast irons, brasses, bronzes, nickel silver, cupro-nickel and other alloys containing nickel. This information is yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Cutting, John B., B.S.M.E., Operating Instructions Engineer, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Draley, Eugene C., B.A.E., Aero. Research Scientist, Langley Aero. Lab., N.A.C.A.

Evans, John R., Flight Engineer, T.W.A., Inc.

Gorgenson, John A., Engineering Designer "A," Douglas Aircraft Co., Inc. (El Segundo).

Hilderman, Richard A., M. of Engineering, Stress Analyst, Grumman Aircraft Engineering Corp.

Randell, Orson B., B.S. in Aero., Engineering Section Head, Sperry Gyroscope Co. Div., The Sperry Corp.

Shone, Douglas J., M.S. in Struct. Mechanics, Sr. Stress Analyst, de Havilland Aircraft Co.

Slate, Herbert B., B.S. in M.E., Application Engineer, Aviation Div., General Electric Co.

Wright, Stephen C., Mechanical Engineer & Dept. Head, Mechanical Design & Manufacture, American Time Products, Inc.

Transferred to MEMBER Grade

Blalock, James E., B. of Ae.E., Asst. Head, Wind Tunnel 2 Section, Aerodynamics Lab., David Taylor Model Basin, Dept. of the Navy.

Broberg, Ralph F., B.S.E. (Aero.), Project Engineer, Aerodynamics Lab., David Taylor Model Basin, Dept. of the Navy.

Perlman, Eliah P., B.S.Ae.E., Aero. Engineer, Pilotless Aircraft Section, Research Div., Bureau of Aeronautics, Dept. of the Navy.

Truman, John C., M.A.E., Instructor, Dept. of Physics, Rensselaer Polytechnic Institute.

Elected to Associate Member Grade

Dawson, William S., Major, U.S.A.F.; Advisor on Weather Communications to the Dir. of Operations, Hq., 1808th Airways & Air Communications Serv., M.A.T.S.

Piersol, Rodney E., Vice-President, Alexander & Alexander, Inc.

Pollitt, C. A. H., M.I.E.D., Free-Lance Aeronautical Journalist.

Elected to Technical Member Grade

Kobayashi, Francis M., M.S., Instructor in Engineering Mechanics, College of Engineering, University of Notre Dame.

Smith, James E., Jr., B. of Applied Sc. in M.E., Jr. Research Officer, Aerodynamics Section, National Research Council.

Transferred to Technical Member Grade

Aberle, Fred W., Draftsman "B," North American Aviation, Inc.

Allison, Malcolm M., B.S.Ae.E.

Brownlee, Kenneth W.

Calhoon, Joseph A., B.A.E., Aero. Engineer, Air Materiel Command, Wright-Patterson Air Force Base.

Carlson, Fred M., Time Study Observer "A," Industrial Engineering Dept., Boeing Airplane Co. (Seattle).

Catlett, John W. C., Jr.

Clarke, Robert H., B.Sc., Engineering Dept. Head, Maurey Mfg. Corp.

Clelland, Jack D., B.S. in Ae.E., Jr. Engineer, Boeing Airplane Co. (Seattle).

Cox, Ernest F., Field & Service Mechanic, Consolidated Vultee Aircraft Corp.

Crabill, Norman L., B. of Ae.E., Aero. Engineer, N.A.C.A., Langley Air Force Base.

Cucuzza, Joseph R., Detail Engineer, Aerojet Engineering Corp.

Cunningham, John A., B.S.

Deering, David J., Engineer—Liaison "A," Northrop Aircraft, Inc.

Delsol, Eugene P., Engineering Draftsman, North American Aviation, Inc.

Dinan, Philip H., Aero. Engineering Trainee, The Glenn L. Martin Co.

Dreschler, Frank, B.S.

Etheridge, Frederick Gordon, B.E. Mathematician—Aerodynamicist, Aerophysics Lab., North American Aviation, Inc.

Fickett, C. Lawrence, Jr. Engineering Draftsman, The Glenn L. Martin Co.

Fitzpatrick, Donald F., B.A.E., Aero Engineer, Flight Test Div., Naval Air Test Center (Patuxent River).

Harry, David W., Drafting Engineer, Transport Equipment Co.

Johnson, Read, Jr., B.S., Jr. Engineer, Engineering Experiment Station, A. & M. College of Texas.

Karol, Walter C., Field Service Representative, North American Aviation, Inc.

Keller, M. R., B.S. in Ae.E.

Kiel, Arthur, Engineer, Technical Training Aids, Inc.

Kneer, Wilbur C., B.S.Ae.E.

Knollenberg, W. George, B.S.M.E. (Aero.), Chief Progress Engineer, Morrison Construction Co., Inc.

Kunze, Franklin C., B. S. in Ae.E., Structures Research Engineer, Bell Aircraft Corp.

Lampi, Edwin H., B.S.

Levin, Allan E., B. of Ae.E.

Lewin, Melvin H., B.S., 2nd Lt., U.S.A.F.; Engineering Officer, Design Section, Exhibit Unit, Air Materiel Command, Wright-Patterson Air Force Base.

Mabuchi, Kenneth K., Layout Draftsman, Hagstrom Co.

Macaulay, Jack R., B.S.

Magann, Wolden, B.S. (Aero.), Stress Engineer, North Americarf Aviation, Inc.

Magistrate, Kenneth C., B.S.Ae.E., Technical Writer, Stanley F. Chamberlain, Inc.

Mannes, Robert L., M.S. (M.E.), Asst. Prof. of Mechanical Engineering, University of Southern California.

(*Continued on facing page*)

I.A.S. National Meeting Schedule

Seventh Annual Personal Aircraft Meeting—Hotel Lassen, Wichita—May 19–20

Annual Summer Meeting—Western Headquarters Building, Los Angeles, July 12–14

Members or organizations wishing to submit papers for presentation at National Meetings should send outlines or summaries to the Committee no later than 5 months prior to the meeting.

All papers submitted will be considered for publication in the *Journal of the Aeronautical Sciences* or the *Aeronautical Engineering Review*.

All correspondence should be addressed to:

The Meetings Committee, Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.

Meeker, Richard P.

Meyers, A. Howard, B.S.Ae.E.

Mutchler, John V., B.S. in Ae.E., Asst. Prof. of Mechanics, Southwestern Louisiana Institute.

Oliver, Richard N., Grapher, Data Reduction, Northrop Aero. Institute.

O'Regan, Dermot F., Aero. Engineering Trainee, The Glenn L. Martin Co.

Prince, George D., Engineering Draftsman "A," Hughes Aircraft Co.

Santy, Joseph T., B.S.

Schmidt, Robert D., B.S. in Ae.E.

Schneider, William C., S.B. (Aero.), Aero. Engineer, Langley Aero. Lab., N.A.C.A.

Schoonover, George N., B.S.

Senkbeil, E. A., B.S. (Aero.), Lt. & Pilot, U.S.A.F. (Keesler Air Force Base).

Sensenbaugh, Norman D., B.S. in Ae.E.

Smith, William J., Jr.

Spraitz, Edward F., B. of Ae.E., Aero. Engineer, National Bureau of Standards (Washington, D.C.).

Stafford, Eugene D., B. of Ae.E., Jr. Engineer, Applied Dynamics Section, Aerophysics Lab., Goodyear Aircraft Corp.

Strigle, John B., B.E., Engineering Draftsman "B," North American Aviation, Inc.

Sunday, W. W., B.S., Staff Experimental Test Pilot, Chance Vought Aircraft Div., United Aircraft Corp.

Thompson, Donald C., Engineering Technician "A," Northrop Aircraft, Inc.

Turner, John E., B.S.

Vaughan, Victor L., Jr., B.S. in Ae.E.

Wang, Alexander Jen, B.S. in A.E., Graduate Student, University of Washington.

Waxer, Leonard J., B.S., Jr. Planning Engineer, Chase Aircraft Co., Inc.

Weaver, Robert C.

Williams, Robert E., B. of Engineering, Development Engineer, AiResearch Mfg. Co.

Wolfard, Robert E., B.S. in M.E. (Aero.), Lt. (j.g.), U.S.C.G.; Damage Control Officer, 2nd Coast Guard Dist. (St. Louis).

Wozer, John T., B.S.Ae.E.

Martin Advertising Cites Vital Roll of Air Power ⟶ ⟶ ⟶

Attention-getting Martin ads like this graphically tell informed, alert American magazine readers everywhere of the important part air power plays in our country's preparedness program. The general public and business circles are reached through the pages of *Time, Newsweek, Pathfinder, Business Week, Fortune* and *U. S. News-World Report.* The men and women who write and edit the news are kept abreast of latest developments through *Editor & Publisher, American Press* and *Publisher's Auxiliary.*

Jet-Powered Poison for Under-sea Raiders

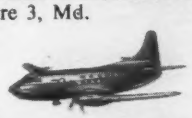
Given top military priority, our anti-sub defenses are being developed at top speed—Martin Mercators are a potent Navy weapon for licking this menace.

Smashing enemy submarines in their pens. Sowing seams of mines to confine them to their harbors. Attacking them en route to their deadly missions. Shepherding convoys. Guarding our continental approaches. These are the vital jobs the speedy Martin Mercator is designed to handle in defending against undersea raiders.

First Navy jet-powered patrol plane, the land-based Mercator is pure poison on the wing to subs. It can sow mines in enemy harbors to keep submarines penned up. It can carry the fight to the enemy with depth charges and torpedoes. It can be equipped with sono-buoys and other modern underwater submarine detection devices.

Most elusive aircraft of its kind ever built, the Navy patrol plane has fighter-type maneuverability—high rate of roll—high rate of climb—lightning-fast response to controls for a plane of its carrying capacity. Two reciprocating engines for economical long-range power—two jets for extra bursts of speed—are uniquely teamed in the P4M Mercator's two nacelles. It's another advanced design produced by the well integrated engineering team Martin offers its customers today! THE GLENN L. MARTIN COMPANY, Baltimore 3, Md.

Seaplane companion of the land-based Mercator in anti-sub warfare, the Martin P5M-1 features a radically longer afterbody for better landing and take-off performance, extra husky construction for anti-sub patrolling from rough seas in dirty weather. First postwar, twin-engine flying boat developed for the U. S. Navy, it is also ideal for air-sea rescue work and cargo carrying.



Great news for air traveller and airline operator alike is the new, pressurized, 40-passenger Martin 4-0-4 Airliner. Already, Eastern Air Lines and Trans World Airline have chosen 65 of these Martin transports to modernize their twin-engine fleets.

Martin
AIRCRAFT
Builders of Dependable Aircraft Since 1909

MANUFACTURERS OF: Dependable Martin airliners • Advanced military aircraft • Revolutionary rockets and missiles • Electronic fire control systems • **DEVELOPERS OF:** Mareng fuel tanks (licensed to U. S. Rubber Company) • Stratovision aerial rebroadcasting (in conjunction with Westinghouse Electric Corp.) • Honeycomb construction material • New type hydraulic automotive and aircraft brake • Permanent fabric flameproofing • **LEADERS IN RESEARCH** to guard the peace, build better living in far-reaching fields.

"BUMPER"

Giant missile born of teamwork!

Miles above the earth, the slender "Wac Corporal" rocket blasts loose from a modified German V-2, and attains a speed of 5,000 mph and an altitude of 250 miles—fastest and highest flight by any rocket. This most successful firing, from White Sands Proving Ground, New Mexico, February 25, 1949, gave scientists important information on little known phenomena of outer space and other data required in missile research.

The "bumper" rocket used in this spectacular test was developed by Army Ordnance working with General Electric, California Institute of Technology Ballistics Research Laboratories, and Douglas Aircraft Company. Structural design of the "bumper" and construction of the "Wac" were among the contributions made by Douglas.

This is just one of the many missiles projects, so vital to America's defense, to which Douglas engineers have been devoting their skill and energies since 1941.

DOUGLAS AIRCRAFT COMPANY, INC., SANTA MONICA, CALIFORNIA

DEPEND ON DOUGLAS

30TH ANNIVERSARY YEAR

Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to Aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

WANTED

Research and Development—Electronics Engineers, Senior—Degree, plus 4–8 years' experience as Project Engineer in radar, design, system, and circuit analysis. **Intermediate** ratings for Electronics Engineers with degree, plus 2–4 years' experience in circuit design, antenna and microwave design. **Electromechanical (Fire Control Systems)**—Degree with at least 4 years' experience in either servomechanisms, analogue computers, or circuitry development. Must have academic training in mathematics. **Electromechanical engineer in flight test, Senior**—Minimum of B.S. degree, but M.S. degree desired. At least 5 years' experience in instrumentation in research laboratory testing and devising new measurement systems. Will be responsible for technical integrity and further development of flight-test instrumentation. **Structures engineer, Senior**—Engineering graduates with at least 3 years' experience in aircraft structural analysis techniques sufficient to adapt and modify equations and analysis methods to meet specific structural problems. Must have good knowledge of report-writing techniques. Those with at least 1½ years' experience will be considered for intermediate openings. **Aerodynamic Engineers, Senior**—Technical graduates with at least 4 years of proved experience in aerodynamics work in either performance, stability and control, air loads or flight-test reduction. Graduates with advanced degrees with thesis in aerodynamics or thermodynamics and at least 2 years' experience in aircraft will also be considered. **Heating and Ventilating Engineer in Aerodynamics, Senior**—Degree and 5 years' experience in aircraft cabin conditioning and anti-icing systems. Knowledge of heat transfer, thermodynamics, and gas dynamics. Familiar with design and installation of cabin conditioning equipment. **Propulsion Engineer, Senior**—Degree and 5 years' experience in air-frame or power-plant development and installation. Familiar with design and operation of power-plant components. Familiar with turboprop, jet, and ram-jet. Background in thermodynamics, fluid dynamics, and gas dynamics. Must be analytical and capable of good analysis report writing. Send résumé to Employment Department, The Glenn L. Martin Company, Baltimore 3, Md.

Thermodynamicist—Graduate engineer to perform design analyses in one or more phases of aircraft power-plant installations, such as duct flow, heat transfer, cabin conditioning, or fuel system analysis. Minimum 2 years' experience. Apply Engineering Personnel Manager, Northrop Aircraft, Inc., Hawthorne, Calif.

Graduate Mechanical or Chemical Engineer—For design and analytical work. To do research on rocket engine components. Experience in combustion, thermodynamics, and heat transfer essential. Additional experience in hydraulics, machine design, and metallurgy desirable. Willingness and ability to use mathematical analysis and theoretical background required. Aerojet Engineering Corporation, P.O. Box 296, Azusa, Calif.

Graduate Mechanical or Chemical Development Test Engineer—To supervise test operations and rocket engine components. Experience in aircraft engine or allied test fields essential. Knowledge of, or experience in, instrumentation, hydraulics, and aircraft hydraulic systems desirable. Should have B.S. degree; advanced degree desirable. Must be willing to accept responsibility entailed in this type of test operation. Aerojet Engineering Corporation, P.O. Box 296, Azusa, Calif.

Engineers—The U.S. Naval Ordnance Experimental Unit has recently been established and is located at the National Bureau of Standards, Washington, D.C. The following vacancies exist in grades GS14, $8,800; GS13, $7,600; and GS12, $6,400; Aeronautical Engineers, Mechanical Engineers, Electronics Engineers. Assignments will include consultation, testing, evaluation, and product engineering in the development of guided missiles and components. Applicants must have had experience, preferably in connection with guided missiles or pilotless aircraft, in one or more of the following fields: Aerodynamics, Propulsion, Structures and Design, Control Mechanisms, Electronics, Production and Manufacture, Requirements and Specifications, and Flight Testing. Project engineer and staff positions are open. Enclose completed copy of Civil Service Application Form 57 (obtainable at local post office) and address inquiries to Officer in Charge, U.S. Naval Ordnance Experimental Unit, National Bureau of Standards, Washington, D.C.

Engineers—Aircraft Instrument—Exceptional opportunity for highly qualified engineers at staff level. A wide range of positions now open in product development and production design. Projects require electronics, electromechanical, and mechanical background. **Application Engineers**—Graduate engineers with extensive design experience in air-frame and/or aircraft accessory field. Work involves application and installation design of aircraft instruments in military aircraft. Knowledge of modern fuel systems desirable. **Electronics Engineers**—Preferably with degree, or equivalent experience, in both aeronautical and electrical engineering. Please send professional résumés to: Leo A. Weiss, President, Aviation Engineering Corporation, 103–30 99th St., Ozone Park 16, N.Y.

142. Sales Executive—Must have extensive sales management experience to direct and coordinate existing sales departments, each dealing in specialized technical fields in administration of Government contracts, sale of specially engineered products to aircraft manufacturers, also selling controls for industrial use, radio in personal airplanes, and sound equipment in specialized consumer fields. Must be experienced in guiding and directing advertising programs and analyzing potential markets and operating records. Technical background desirable but not essential. Good business judgment and operating and planning experience required. Our employees know of this advertisement. Location, Mid-West.

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

AVAILABLE

163. Aeronautical-Mechanical Engineer—B.S. in Ae.E., January, 1950; "A" average. One year time and motion study in night school. One year's experience in product design (industrial magnets). Three years in Naval Air Service as aviation mechanic and air cadet. Holds private pilot's license. Age 23. Location open. Available for interview.

162. Aeronautical Engineer—Graduate of the Academy of Aeronautics. Two years' experience in aircraft design. Familiar with fabrication procedures. Age 27. Primarily interested in design.

161. University Teaching—Wind-Tunnel Operation—Wind-tunnel assistantship, and M.S. in Aeronautics, Cal. Tech. Ten years' experience in all phases aerodynamics with several aircraft manufacturers. Specializing in wind-tunnel testing, including model design, testing, and tunnel operation, analysis of results, and company representation. Position teaching and wind-tunnel operation desired.

160. Aeronautical Engineer—B. Aero. E., R.P.I. (1949). Five months' experience with jet engines. Two months' experience as operator of Packard-powered test rig. College training in both jet and reciprocating engines. Built variable compression ratio engine as undergraduate thesis. Training in aerodynamics includes course in compressible flow. Desires position in research or development group in either power plants or aerodynamics. Single. Location open. Available for interview.

158. Aeronautical Engineer—Recent graduate in Aeronautical Engineering, equivalent of four years' intensive study. Familiar with aircraft materials, limitations, tolerances, processing, and production. Seven months' experience with actual data reduction for guided-missile telemetering. One year's experience as airplane and engine mechanic on two- and four-engined aircraft. Desires junior position that requires mechanical inclinations with engineering thinking. Location open. Age 23.

157. Aeronautical Engineer—Age 24. Graduate of Academy of Aeronautics in Aircraft Design and Construction, August, 1949. Two years' civilian and 1½ years' military experience in aircraft, instrument, and engine overhaul and maintenance on transport aircraft. Background includes "A" license. Six months with aircraft engine manufacturer as tester of experimental jet engines and accessories. Desires position as junior engineer in or about New York City area.

156. Aeronautical Engineer—Age 24. Graduate of Stewart Aviation School, design course. Two years' mechanical design experience. Won I.A.S. student lecture award and also student aircraft design award. Flight engineer on B-17 (8th Air Force) during war, 2,500 hours' flight time. Graduate of various Air Force schools. Prefers aircraft design or flight testing. Location open.

155. Research Engineer—Bachelor of Aeronautical Engineering. Four years' experience in over-all aerodynamic and analytical studies pertaining to design of all types supersonic guided missiles and aircraft. Desires responsible position with aircraft company, research facility, or university located in East or Middle West. Position need not be in field of supersonic research; opportunities for independent and interesting work most desirable.

154. Jet Propulsion and Aeronautical Engineer—B.S., M.S. Aero E. Twelve years' experience in aircraft and liquid rocket design. Last 4 years as liquid rocket and jet propulsion design group leader. Previous 8 years as aircraft structural design engineer, group leader, and project engineer. Qualified engineer, organizer, supervisor, and administrator. Age 34. Desires responsible position in liquid rocket or jet propulsion field or aircraft design (utilizing jet power).

153. Engineer—Young man desires research or teaching position with educational institution. Doctor's degree in Aeronautical Engineering, considerable research experience. Has been in responsible charge of theoretical and experimental research projects in the fields of structures, elasticity, and aerodynamics. Some teaching and industrial experience. Several publications. Location open.

152. Aeronautical Engineer—B.S. Degree in Aeronautical Engineering. Two years' experience in transonic wind-tunnel work comprising wind-tunnel operation, balance calibrations, data reduction, and development work. Previously, four years' experience in the army Air Force as Engineering Officer in charge of heavy bombardment aircraft maintenance. Also experience in lofting and perspective drawings. Desires position in aerodynamics, development work, or other related engineering work. Other engineering fields will be considered. Age 28.

151. Manufacturers Military Sales Representative—Aeronautical Engineer, B.AeE. Fourteen years' experience both in the aviation industry and the Air Materiel Command at Wright Field. Positions in industry included project engineer, staff engineer and factory representative to the Air Materiel Command, covering both technical and administrative duties. Duties with A.M.C. included design, stress analysis, airplane project engineer, which afforded close and frequent contact with both A.M.C. and aviation industry engineers. Can be of value to aeronautical equipment manufacturer seeking Air Force contracts or currently a contractor to the Air Forces.

150. Aeronautical Engineer—B.S. in Mechanical Engineering (Aeronautical Option) from Purdue University. Eight years of experience in aerodynamics, ground and flight testing, powerplant installation design, preliminary aircraft design, project engineering, and project administration. Has worked on piloted and pilotless aircraft of most classes and on reciprocating, turboprop, turbojet and pulse-jet power plants. Exceptional talent for, and experience in, the preparation of engineering reports and proposals. Familiar with technical aspects of Navy and Air Force contracts. Long experience in the preparation of correspondence to the armed services. Able to plan, organize, and schedule any type of engineering project. Registered professional Engineer, State of California. Prefers location in Los Angeles area. Immediately available.

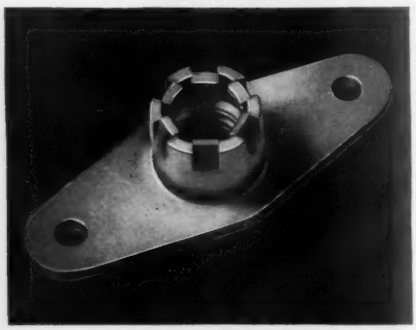
149. Aeronautical Engineer—B.S.Ae.E. Approximately 5 years' engineering experience. One and one-half years in aerodynamic development of advanced aircraft. Last 2½ years as subsonic and transonic wind-tunnel test engineer. Ability in technical writing and graphic design studies. Some mechanism design experience. Has had business training. Desires position of responsibility in development of aircraft and component design or in research, air line or industry. Age 29.

148. Aeronautical Engineer—Bachelor of Aeronautical Engineering degree, North Carolina State College, 1943. Fifteen months of detail drafting and design, with 6 months on wind-tunnel test models for leading Navy fighter manufacturer. Three and one-half years' experience in U.S. Marine Corps as airplane and engine mechanic with carrier and land-based fighter squadrons. Prefers position on East Coast. Age 29.

147. Aeronautical Engineer—B.S. in M.E., and Aero Option, graduate credits. Two years' experience in flight research with reciprocating, turbojet, and rocket-powered aircraft. Four years' experience with rocket propulsion systems, theoretical analysis, design, shop practice, testing, development, and reports. Extensive administrative work throughout. Successful liaison work with the Services and vendors. Desires part-time position Long Island or Connecticut requiring broad application of past experience. Age 28.

146. Aeronautical Engineer—Structures—Graduate M.I.T., 1938, B.S. Ten years in Aeronautical Structures. Specialized in electric strain-gage analysis and recording. Familiar with air-frame production methods, sheet-metal forming, and plasticity of light alloys. Commercial pilot with multiengined and instrument ratings. Desires structures flight-testing position.

SAFETY-FAST



NEW **BOOTS** SELF-LOCKING

PLATE-LOK

ONE PIECE: all-metal, one-piece construction assures a more rugged assembly, longer life, high reusability, less weight.

TWO JOBS IN ONE: the Hex-Lok principle in the new Plate-Lok provides fastening and locking surfaces integrated in one sound structural unit.

THREE SAFETY FACTORS: the new Boots Plate-Lok: 1. Resists extreme vibration even through periods of radical temperature changes; 2. Resists deteriorating influences which attack non-metal substances; 3. Maintains full locking strength under sustained temperatures up to 550 degrees, which eliminates the cost of procuring and stocking lower temperature lock-nuts.

Plate-Loks use the Hex-Lok principle—that means high torque retention, high reusability, simplified maintenance, less weight. Meets AN Specifications.

Also available

BASKET TYPE

CHANNEL TYPE

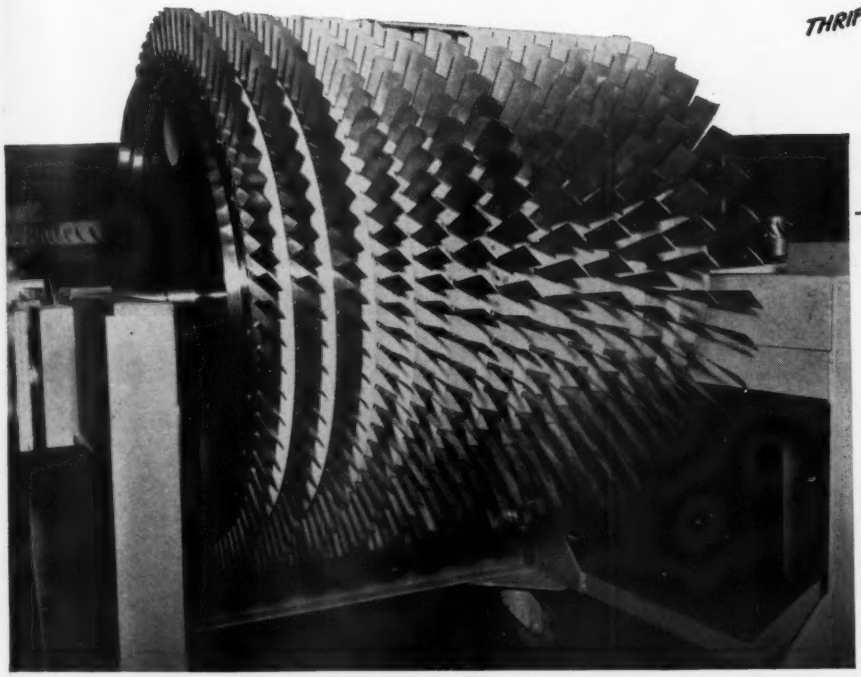
HEX-LOK

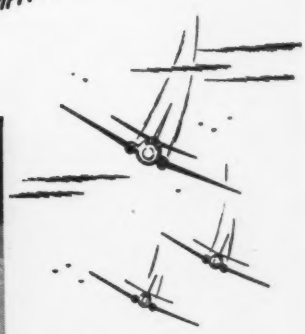
Problems? *Send us complete details. We'll supply experimental quantities free.*
Literature. *Write now for the new Boots Catalog soon to be released.*

BOOTS *Aircraft Nut Corporation*
STAMFORD, CONNECTICUT

Enduro® STAINLESS STEEL

THRIFTY METAL OF 10,000 USES





1840 Stainless Steel blades give this jet engine rotor compressor the appearance of a porcupine ready for battle. In addition to heat-resistance, corrosion-resistance also is a vital requirement of these and other jet engine parts, due to the corrosive atmospheres encountered in coastal area operations. Republic ENDURO fills the bill on both counts.

FOR THE FLASHING FINS OF A TORNADO-MAKER

Heat that would wilt less sturdy materials—heat such as encountered in jet engines—finds its match in lasting Republic ENDURO Stainless Steel. Yet, ability to retain its high strength at high temperatures is only one of ENDURO's all-important virtues to the aircraft designer.

This modern miracle metal affords utmost resistance to corrosion and oxidation. It has high tensile and impact strength. In certain analyses, it is non-magnetic. And because it fabricates readily and easily, it presents no production problems to hamstring the design engineer.

Here indeed is the economical material for aircraft construction . . . economical because it does so many jobs so well and, in those jobs, is unsurpassed for lasting dependability.

Now is the time to learn more about versatile ENDURO Stainless Steel and its ability to aid in the solution of design problems.

✓ **CHECK ALL 12 ADVANTAGES: Rust- and Corrosion-Resistance • Heat-Resistance • High Melting Point • Low Coefficient of Expansion • High Strength • Good Dimensional Stability • No Metallic Contamination • Easy to Clean • Easy to Fabricate • Eye Appeal • Long Life • Low End Cost • *What more can be desired in a material?***

REPUBLIC STEEL

For Complete Details Write

REPUBLIC STEEL CORPORATION

Alloy Steel Division, Massillon, Ohio • **GENERAL OFFICES, CLEVELAND 1, OHIO** • *Export Dept.: Chrysler Bldg., New York 17, N.Y.*

METAL GROWS, TOO!

Take a block of one of the toughest aluminum alloys known and chisel from it a high-speed turbine fan rotor like that shown above. Grind and polish to tolerances of one ten-thousandth of an inch—and you'd think it would be accurate enough.

But to give lasting performance in the cooling and pressurizing equipment built by AiResearch for today's supersonic jet airplanes, such high-speed wheels must be "grown" to perfection.

Each wheel, fan or rotor is placed in a vacuum test chamber resembling a wall safe. Here it is test-spun at speeds up to 150,000 rpm. Frosted coils control heat of air friction. At this enormous speed, the metal actually "grows" or expands—as much as 3/1000 of an inch—either revealing structural defects or releasing internal tension and achieving complete dimensional stability.

Such pioneering in design, manufacture and laboratory testing of precision equipment is typical of the day-to-day operations of the skilled scientists and engineers at work at AiResearch.

● Whatever your field — AiResearch engineers — designers and manufacturers of rotors operating in excess of 100,000 rpm — invite your toughest problems involving high-speed wheels. Specialized experience is also available in creating compact turbines and compressors; actuators with high-speed rotors; air, gas and liquid heat exchangers; air pressure, temperature, electronic and many other automatic controls.

AiResearch
DIVISION OF
THE GARRETT CORPORATION

● *An inquiry on your company letterhead will get prompt attention. AiResearch Manufacturing Co., Los Angeles 45, Calif.*

Index to Advertisers

A

Aeroproducts Division, General Motors Corporation.... 55
Air Reduction Company, Inc., Ohio Chemical & Surgical Equipment Company Division 10
★Airborne Accessories Corporation..... 8
AiResearch Manufacturing Company Division, The Garrett Corporation..... 94

B

B. H. Aircraft Company Inc..... 81
★Bendix Aviation Corporation
★Bendix Products Division..... 4
★Eclipse-Pioneer Division.....Inside Front Cover
★Scintilla Magneto Division..... 63
Boots Aircraft Nut Corporation..... 92

C

Cal-Aero Technical Institute..... 83
Chicago Metal Hose Corporation..... 70
★Clifford Manufacturing Company Division, Standard-Thomson Corporation.....Inside Back Cover
Consolidated Vultee Aircraft Corporation..... 83
★Curtiss-Wright Corporation
★Propeller Division..... 85
★Wright Aeronautical Corporation Division..... 96

D

Douglas Aircraft Company, Inc..... 90

E

★Eclipse-Pioneer Division, Bendix Aviation Corporation.....Inside Front Cover
★Electrol, Incorporated.....Back Cover

F

Foote Bros. Gear and Machine Corporation..... 2
Futuraire Engineering..... 83

G

G&O Manufacturing Company, The..... 86
Garrett Corporation, The, AiResearch Manufacturing Company Division..... 94
General Motors Corporation, Aeroproducts Division.... 55
G. M. Giannini & Company, Inc..... 10
Goodyear Tire & Rubber Company, Aviation Products Division..... 1

H

Holley Carburetor Company..... 48
Hydropress, Inc..... 67

I.A.S. Publications..... 77
Imperial Pencil Tracing Cloth, Keuffel & Esser Company.. 80
International Nickel Company, Inc., The..... 87

J

★Jack & Heintz Precision Industries, Inc..... 53

K

Keuffel & Esser Company, Imperial Pencil Tracing Cloth.. 80
Kollsman Instrument Division, Square D Company..... 82

L

Lamb Electric Company, The..... 13
Linear, Inc..... 50
Lockheed Aircraft Corporation.....74, 75
Lord Manufacturing Company..... 80

M

★Marman Products Company Inc..... 12
Glenn L. Martin Company, The.....83, 89
Minneapolis-Honeywell Regulator Company..... 83

O

Ohio Chemical & Surgical Equipment Company Division, Air Reduction Company, Inc..... 10

P

Pacific Scientific Company..... 61

R

Republic Steel Corporation, Alloy Steel Division..... 93
★Rohr Aircraft Corporation..... 79

S

★Scintilla Magneto Division, Bendix Aviation Corporation..... 63
Servomechanisms Inc..... 86
★Sperry Gyroscope Company, Division of The Sperry Corporation..... 59
Square D Company, Kollsman Instrument Division..... 82
J. S. Staedtler, Inc..... 75
★Standard-Thomson Corporation, Clifford Manufacturing Company Division.....Inside Back Cover
Surface Combustion Corporetion, Aircraft-Automotive Division..... 57

T

H. I. Thompson Company, The..... 72

U

United States Aviation Underwriters Incorporated..... 10

V

Vellumoid Company, The..... 83

W

John Wiley & Sons, Inc..... 83
★Wright Aeronautical Corporation Division, Curtiss-Wright Corporation..... 96

Y

Young Testing Machine Company..... 10

★ *Specifications and further information on the aircraft products of these companies will be found in the*

1950 AERONAUTICAL ENGINEERING CATALOG

The only publication of its kind devoted exclusively to the aircraft industry, this CATALOG serves as a valuable buyers' and reference guide to sources and specifications on aircraft materials, parts, and accessories. It is distributed annually to Chief Engineers, Designers, Production Heads, and Purchasing Departments of all leading Aircraft, Aircraft Engine, Instrument, Accessory, and Aircraft Parts Manufacturers; Air Transport Companies; Army, Navy, and Governmental Agencies; Research Organizations; Engineering Libraries; etc.

Published Annually by

INSTITUTE OF THE AERONAUTICAL SCIENCES

2 East 64th Street New York 21, N.Y.

Ram Jets get a 'Flight Engineer'

▶ A ***human*** flight engineer would have to shrink to the size of a gremlin to operate a ram jet. He would have to withstand temperatures from −100F. to +700F.... pressures from that at 100 feet under water to that at 80,000 feet in the air. On top of that... calculate and react in less than a second to complex mathematical problems.

▶ Yet the ram jet needs a flight engineer... and gets one in Wright Aeronautical's new ***power control system.*** It performs ***automatically*** the functions of a flight engineer on a modern airliner.

▶ Actually it does a great deal more, for in ram jet operation, where supersonic speeds prevail, much wider ranges of air flow, temperatures and pressures are encountered than in any previous-type aircraft. The power control checks instantaneous changes in air density, determines the jet's fuel requirements, and actuates the missile's controls in a fraction of a second. Result... smooth, highly efficient engine performance.

▶ These power control units—and all other ram jet components—are now under development in Wright Aeronautical's new ram jet laboratory. Here is another indication of this company's leadership in supersonic ram jet research and development.

Wright Aeronautical Corporation, Wood-Ridge, New Jersey

CURTISS WRIGHT